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ABSTRACT

Eight student learning guides are provided for a medical assisting program at the secondary, postsecondary, or adult level. Each learning guide is composed of these component parts: a title page that states the task, purpose, program and task numbers, estimated time, and prerequisites; an optional learning contract that includes terminal performance and intermediate objectives; materials for each intermediate objective; and a criterion exam. For each objective some or all of the following may be included: learning steps/activities and related resources, information sheets, job sheets, activity sheets, and a self-help evaluation instrument. The learning guides cover the following eight tasks: demonstrating use of balances, performing pipetting, operating a centrifuge, measuring and calculating dosage, performing reticulocyte count, performing bleeding and capillary coagulation tests, preparing solutions, and performing a mononucleosis test. (YLB)

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Medical Assisting Learning Guides

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Product Abstract

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Competency-based learning guides for learning basic skills/knowledge

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Grayslake IL 60030

LEARNING GUIDE TITLES

1. Demonstrate use of balances
2. Perform pipetting
3. Measure and calculate dosage
4. Operate centrifuge
5. Perform reticulocyte count
6. Perform bleeding and capillary coagulation times
7. Prepare solutions
8. Perform mononucleosis test

LAKE COUNTY AREA VOCATIONAL CENTER

COMPETENCY-BASED INDIVIDUALIZED VOCATIONAL EDUCATION INSTRUCTION

STUDENT LEARNING GUIDE

Produced By Rosemarie Meyer Date 11/84

TASK: DEMONSTRATE USE OF BALANCES

PURPOSE: Many and varied pieces of laboratory apparatus are used in performing clinical determinations, and the knowledge of the proper use and handling of this equipment is an important part of any course of study dealing with laboratory work. Probably some of the most important instruments are the various types of balances used to measure weight or mass (gravimetric analysis) in preparing the reagents and standard solutions used in the laboratory. This learning guide will assist you to demonstrate the use of balances.

emf

MEDICAL ASSISTING

Program	Task	Est.Time	Prereq.
07.0904	002E	6 hrs.	

LEARNING CONTRACT (optional)

1. STUDENT DATA

NAME _____ SOCIAL SECURITY NUMBER _____

LENGTH OF CONTRACT (NORMAL TIME IN HOURS) 6 Hours

2. TERMINAL PERFORMANCE OBJECTIVE

Given the necessary tools and equipment, demonstrate the use of balances. To master this task you must score 24 out of 24 (100%) on a performance evaluation and 14 out of 15 (90%) on a written evaluation.

2a. INTERMEDIATE OBJECTIVE(s)

1. Describe types of balances.
2. Demonstrate use of balances.

3. AGREEMENT

I, _____ agree to complete the above stated terminal performance requirement within _____ to _____ I further recognize that the conditions of the contract (performance and time agreement) report my ability to perform the requirements of the occupation and record my progress.

_____ Student's Signature

_____ Instructor's Signature (verifies competency)

INTERMEDIATE OBJECTIVE #1

DESCRIBE TYPES OF BALANCES.

LEARNING STEPS (Activities)

1. Read Resource #1 for information on types of balances and the use of balances.

2. View Resource #2 for a visual presentation on the types of balances and their uses.

3. Complete Resource #3 for a review on types of balances and their use.

4. Proceed to Resource #4.

RESOURCES

1. Information Sheet 002E-001-001, "Types of Balances," Page 3 in this SLG.

   Information taken from textbook: "Basic Techniques for the Medical Laboratory" by Linne and Ringsrud, 2nd edition, McGraw Hill Book Co.

2. Biotech 8107, in the LRC.

   See LRC Secretary.

3. Job Sheet 002E-001-001 "Review Types of Balances and Their Uses," pages 12 - 14 in this SLG.

4. IO #2, page 15 in this SLG.

WEIGHING AND THE USE OF BALANCES

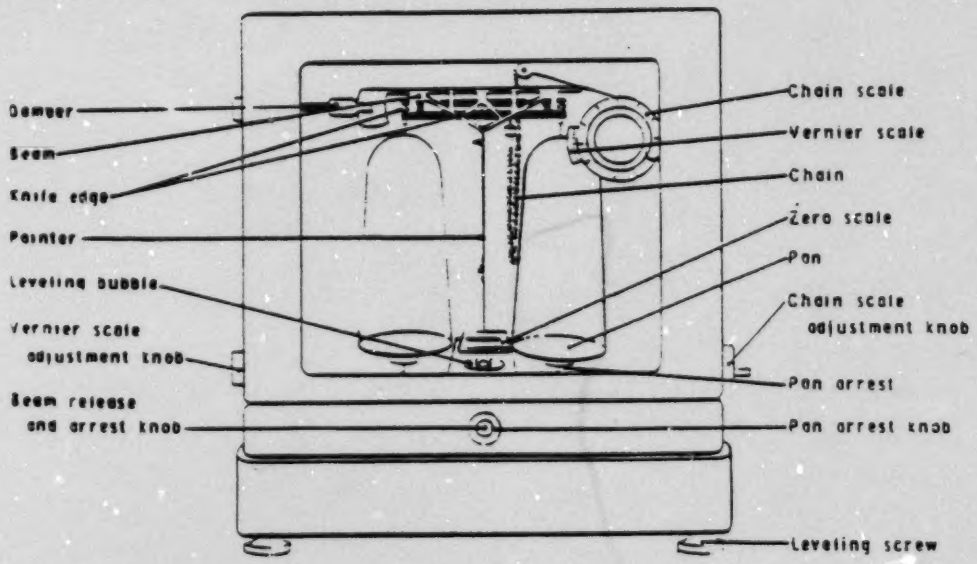
Many and varied pieces of laboratory apparatus are used in performing clinical determinations, and the knowledge of the proper use and handling of this equipment is an important part of any course of study dealing with laboratory work. Probably some of the most important instruments are the various types of balances used to measure weight or mass (gravimetric analysis) in preparing the reagents and standard solutions used in the laboratory. This is a method of quantitative analysis in the laboratory. Almost every procedure performed in the laboratory depends to some extent on the use of a balance. The balance considered to be the "backbone" of the clinical chemistry laboratory is the analytical balance. This balance and other types—namely the triple-beam, Cent-O-Gram, and torsion balances—will be discussed in this section. A single laboratory is likely to have all of these types, and for this reason a student in a laboratory course should understand how the various balances work. Every laboratory should have some type of analytical balance and at least one other less sensitive type of balance. These are the minimum requirements for weighing instruments.

Balances are used to weigh the chemicals used to prepare the many chemical solutions needed in the laboratory. Some solutions require more accurately weighed chemicals than others. The accuracy needed depends on what the solution is to be used for. One must decide what type of balance (or scale) is most appropriate for the precision or reproducibility required in weighing the chemicals to be used for a particular solution. The different kinds of balances are suited to particular needs. A balance that sacrifices precision for speed should not be used when precision is needed.

Analytical balance

Many different types of analytical balances are made by different companies and they have

Fig. 1-8. Manual analytical balance.



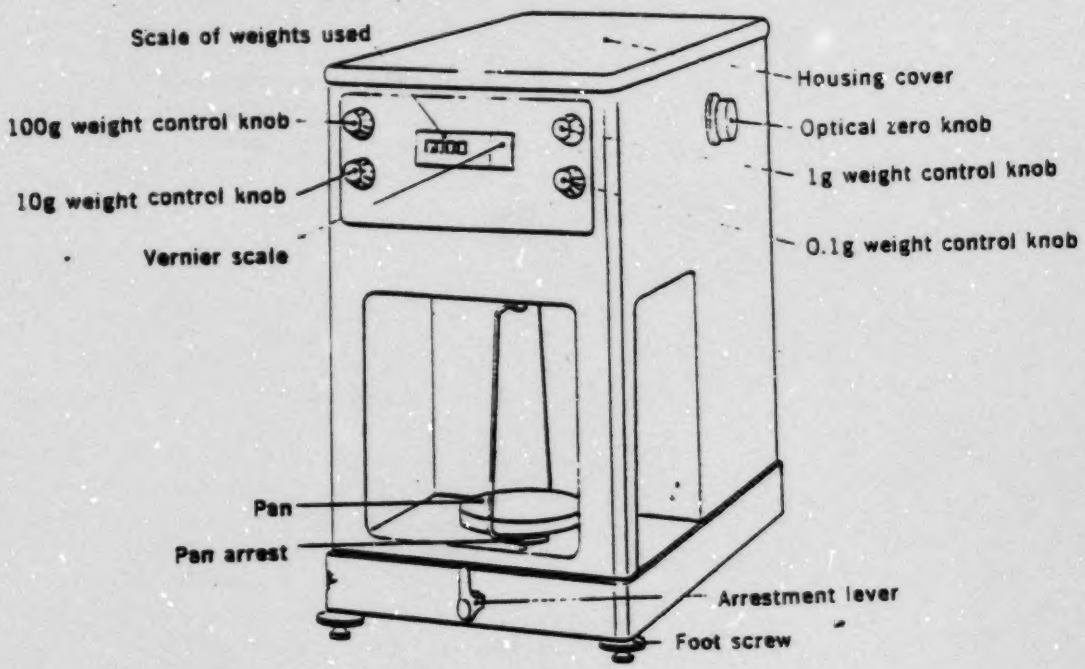


Fig. 1-9. Automatic analytical balance.

various degrees of automatic operation. In this discussion analytical balances are divided into two types: manually operated analytical (Fig. 1-8) and automatic analytical (Fig. 1-9) balances. Each company that manufactures analytical balances has its own special name for each of the various automatic analytical balances produced. All analytical balances are used to weigh very small amounts of substances with a high degree of accuracy, but just how this is accomplished differs slightly from one balance to another. Some require little or no manual operation, and some are more time-consuming and require much more manipulation on the part of the operator. Some of the fine analytical balances manufactured for use in the clinical laboratory are the Ainsworth, Voland, Gram-atic, Christian-Becker, Mettler, and Sartorius balances. Others are also available. It is important to investigate carefully several different analytical balances before deciding on one for use in a particular laboratory.

As stated previously, almost every procedure performed in the laboratory depends on the use of balances, the most important one being the analytical balance. Before any procedure is started, reagents must be prepared and standard solutions made. Standard solutions are always very accurately prepared, and the analytical balance is used to weigh the chemicals for these solutions. The analytical balance might be called the starting point of each method used in the laboratory. Its accuracy determines the accuracy of many clinical determinations. An instrument that is so sensitive and so essential must be made with great skill and treated very carefully by those using it.

The analytical balance should be cleaned and adjusted at least once a year to ensure its continued accuracy and sensitivity. Its accuracy is what makes this instrument so essential in the clinical laboratory. The accuracy to which most analytical balances used in the clinical laboratory

should weigh chemicals is commonly 0.1 mg, or 0.0001 g. Whenever this accuracy is needed, the analytical balance must be used. Differences between automatic and manual analytical balances lie mainly in the manner in which the weights are added in the weighing procedure. In the manual balance the weights are actually placed on one of the balance pans by hand. In the automatic balance the weights are added by manipulating a series of dials.

It is essential that the parts of the analytical balance be thoroughly understood, so that the weighing process can be carried out to the degree of accuracy necessary. Once the correct use of an analytical balance has been mastered, one should be able to use any of the available types, as they all have the same basic parts. Each manufacturer supplies a complete manual of operating directions, as well as information on the general use and care of the balance, with each balance purchased. These directions should be followed closely.

Basic parts

1. *Glass enclosure.* The analytical balance is enclosed in glass to prevent currents of air and collection of dust from disturbing the process of weighing.

2. *Balancing screws.* Before doing any weighing on the balance, it must be properly leveled. This is done by observing the leveling bubbles, or spirit level, located near the bottom of the balance. If necessary, adjust the balancing screws located on the bottom of the balance case (usually found on each leg of the balance).

3. *Beam.* This is the structure from which the pans are suspended.

4. *Knife edges.* These support the beam at the fulcrum during weighing and give sensitivity to the balance. Knife edges are vital parts and are constructed of hard metals to give a minimum amount of friction.

5. *Pans for weighing.* In the manually operated analytical balance, there are two pans: the weights are placed on the right-hand pan and the object to be weighed is placed on the left-hand pan. In the automatic analytical balance, there is only one pan. The object to be weighed is placed on this pan. The pans are suspended from the ends of the beam.

6. *Weights.* In the manual balance, the weights are found in a separate weight box. These weights are never handled with the fingers but are removed from the box and placed on the balance pan by using ivory-tipped forceps. Mishandling of weights, either by using the fingers or by dropping, can result in an alteration of the actual and true mass of the weight. Weights come in units ranging from a 50-g to a 100-mg weight. The values of the weights are stamped directly on top of them. In the automatic analytical balance, the weights are inside the instrument and are not seen by the operator unless there is need to remove the casing for repair or adjustment. The weights are added by manipulating specific dials calibrated for the weighing process. The built-in weights are on the same end of the beam as the sample pan and are counterbalanced by a fixed weight at the opposite end; they are removed from above the pan when an object is weighed. There is always a constant load on the beam, and the projected scale has the same weight regardless of the load. The total weight of an object is registered automatically by a digital counter or in conjunction with an optical scale.

7. *Pan arrest.* This is a means of arresting the pan so that sudden movement or addition of weights or chemical will not injure the delicate knife edges. The pan arrests (usually found under the pans) can absorb any shock due to weight inequalities, so that the knife edges are not subjected to this shock. The pan must be released to swing freely during actual weighing. In the automatic analytical balance the arresting mechanism for both the pan and the beam is operated by a single lever. Partial release or full release can be obtained, depending on how the lever is moved.

8. *Damping device.* This is necessary to arrest

the swing of the beam in the shortest practical time, thus cutting down the time consumed in the weighing process.

9. *Vernier scale.* This is the small scale used to obtain precise readings to the nearest 0.1 mg. It is used in conjunction with the large reading scale to obtain the necessary readings.

10. *Reading scale.* In the manual analytical balance, this scale is actually the reading scale for the chain that is used for weighing 100 mg or less. It is used in conjunction with the vernier scale to obtain readings to the nearest 0.1 mg. In the automatic analytical balance, this is usually a lighted optical scale, giving a high magnification and sharp definition for easier reading. The total weight of the object in question is registered automatically on this viewing scale.

General rules for use of the analytical balance

Weighing errors will occur if the balance is not properly positioned. It is therefore very important that the balance be located and mounted in an optimal position. The balance must be level. This is usually accomplished by adjusting the movable screws on the legs of the balance. The firmness of support is also important. The bench or table on which the balance rests must be rigid and free from vibrations. Preferably the room in which the balance is set up should have constant temperature and humidity. Ideally, the analytical balance should be in an air-conditioned room. The temperature factor is most important. The balance should not be placed near hot objects such as radiators, flames, stills, or electric ovens. Likewise, it should not be placed near cold objects, especially not near an open window. Sunlight or illumination from high-power lamps should be avoided in choosing a good location for the analytical balance.

The analytical balance is a delicate precision instrument, which will not function properly if abused. When learning to use an analytical balance, students should make themselves responsible for knowing and adhering to the rules for the use of the particular balance with which they are provided. The following general rules apply:

1. Set up the balance where it will be free from vibration.
2. Load and unload the balance only when the pans are arrested; if the pans are not arrested, the delicate knife edges can be damaged.
3. Close the balance case before observing the reading; any air currents present would affect the weighing process.
4. Never weigh any chemical directly on the pan; a container of some type must be used for the chemical.
5. Never place a hot object on the balance pan. If an object is warm, the weight determined will be too light because of convection currents set up by the rising heated air.
6. Whenever the shape of the object to be weighed permits, handle it with tongs or forceps. Round objects such as weighing bottles may be handled with the fingers, but take care to prevent weight changes caused by moisture from the hand. Do not hold any object longer than necessary.
7. On completion of weighing, remove all objects and clean up any chemical spilled on the pans or within the balance area. Close the balance case.
8. Weighed materials should be transferred to labeled containers or made into solutions immediately.

Speed in weighing is obtained only through practice.

Procedure for weighing with a manual analytical balance

1. Sitting directly in front of the center of the balance, dust off the pans and the inside of the balance with a soft brush.

2. Check to see that the balance is level by observing the leveling bubbles. Make any necessary adjustment by means of the leveling screws on the legs of the balance.

3. To adjust the balance to a beginning reading of zero, lower the beam and release the pan arrests, making certain that the chain reading scale and the vernier scale are both set at zero. Note where the pointer comes to rest, and slowly move the chain until the pointer rests exactly at zero. Arrest the pans and raise and lock the beam. Recheck by repeating these same steps once again. The pointer should still rest exactly at zero. By use of the vernier scale adjustment knob, adjust the zero of the vernier scale to match the zero of the chain reading scale.

4. With the beam raised and locked and the pans arrested, place the weighing vessel on the left-hand pan, using tongs if possible.

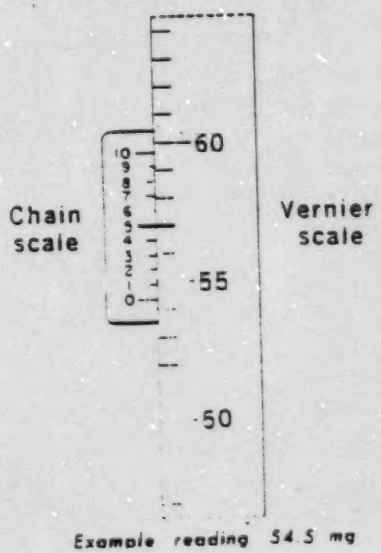
5. From the box of weights provided with the balance, transfer the first weight to the right-hand pan, using the special forceps. Choose a rather large weight as the first weight: 20-g weight would be satisfactory for most purposes. Lower the beam and release the pan arrests. Note where the pointer swings in relation to the zero point. If the pointer swings to the left, the weight is heavier than the vessel. If the pointer swings to the right, the weight is lighter than the vessel. Arrest the pans, and raise and lock the beam.

6. Depending on the direction of the pointer's swing in the previous step, either add another weight from the box of weights, or remove the 20-g weight and replace it with a lighter one (10 g). Repeat this process by adding and removing weights (being certain to raise and lock the beam and arrest the pans before each change of weights) until the addition of the smallest weight in the box (100 mg) causes the pointer to swing to the left. Close the balance window.

7. At this point add weight from the chain. The chain has a total weight of 100 mg and is used when no further weights from the box can be used. With the beam locked and the pans arrested, add 50 mg from the chain by moving the chain scale adjustment knob. Lower the beam and release the pans. Observe the pointer. Again, if the pointer swings to the left the chain weight is too light, and more weight must be added. Raise the beam and arrest the pans. Depending on the swing of the pointer, either add weight by moving the chain by 20-mg steps until the addition of 20 mg causes the pointer to swing to the left, or remove weight by 20-mg steps until the pointer swings to the right. When the chain weight has been narrowed down to within 10 mg of true balance, leave the beam lowered and the pans released, and gradually add or remove weight until balance is obtained. The weighing vessel has now been weighed, and the actual weighing of the desired chemical can commence. Record the weights used to obtain balance with the weighing vessel. To obtain the reading to the nearest 0.1 mg, the vernier scale (Fig. 1-10) must be used in conjunction with the chain scale. Raise the beam and arrest the pans.

8. To the weight of the weighing vessel add the amount of chemical to be weighed. For example, if the weighing vessel weighs 35.5646 g and the amount of chemical to be weighed is 10.5555 g, the total weight is 46.1201 g. This total weight should be on the right-hand pan. To

Fig. 1-10. Reading obtained with a vernier scale.



accomplish this, add the necessary weights from the box of weights and the chain scale to make up the difference.

9. Add the chemical in small amounts, using a clean spatula until balance is achieved. Before each addition of chemical raise the beam and arrest the pans. When balance is obtained, the amount of chemical has been weighed in the weighing vessel. Then transfer it quantitatively to a flask for dilution (see under Quantitative Transfer).

10. Return all weights to the box, return the chain to zero, and clean up any spilled chemical from the balance area. Leave the beam in a raised and locked position, and arrest the pans.

Procedure for weighing with an automatic analytical balance

1. Before doing any weighing, make certain that the balance is properly leveled. Observe the spirit level (leveling bubble), and adjust the leveling screws on the legs of the balance if necessary.

2. To check the zero point adjustment, fully release the balance and turn the adjustment knob clockwise as far as it will go. The optical scale zero should indicate three divisions below zero on the vernier scale. Using the same adjustment knob, adjust the optical scale zero so that it aligns exactly with the zero line on the vernier scale. Arrest the balance.

3. With the balance arrested, place the weighing vessel on the pan, using tongs if possible, so that no humidity or heat is brought into the weighing chamber by the hands. Close the balance window.

4. Weigh the vessel in the following manner: partially release the balance and turn the 100-g weight control knob clockwise. When the scale moves up, turn the knob back one step. Repeat this operation with the 10-g, 1-g, and 0.1-g knobs, in that order. Arrest the balance. After a short pause, release the balance, and allow the scale to come to rest. Read the result and arrest the balance. With the balance arrested, unload the pan and bring all knobs back to zero.

5. Add the weight of the sample desired to the weight of the vessel just weighed to get the total to be weighed. Set the knobs (100, 10, 1, and 0.1 g) to the correct total weight needed. When the 0.1-g knob has been set at its proper reading, the balance should be placed in partial release. Slowly add the chemical to the vessel until the optical scale begins to move downward. When the optical scale starts downward, fully release the beam, and continue to add the chemical until the optical scale registers the exact position desired. To obtain the reading to the nearest 0.1 mg (the sensitivity of most analytical balances), the vernier scale must be used in much the same manner as in the manual analytical balance readings.

6. With the balance arrested, unload the pan, and bring all the knobs back to zero. Clean up any spilled chemical in the balance area.

Torsion balance

These balances are used mainly for weighing chemicals in the laboratory. They are sensitive, responsive instruments with an exceptionally long service life, during which there is no significant deterioration in performance. In normal use, they require very little maintenance. The unique attributes of the torsion balance movement, which is assembled as a single flexible structure by means of highly tensed torsion bands of watch-spring alloy, eliminate the use of knife edges, bearings, and other loose parts that would become dull, misaligned, and soiled. Having no knife edges to dull or other loose parts to be adjusted accounts for the popularity of the torsion balance. Little or no adjustment is required, and this is important in a laboratory, where the time element is so important.

The torsion balance has high sensitivity under a heavy load, permits fast weighing, and is relatively inexpensive. Care must be taken to avoid

overloading these balances. Some models have a dial-controlled torque spring to eliminate the use of smaller loose weights. Other models are offered with dial-controlled built-in weights, which may further reduce the number of loose weights required. Many weighing determinations can be completed in about one-fifth the time formerly required. A sliding tare weight is provided to counterbalance the weighing vessel used. The beam is operated by a lever on the balance case. Some torsion balances are enclosed completely in glass or metal cases. Several of these balances have a damping feature, which brings the balance to equilibrium quickly. One such damping device is an oil dashpot, which is filled at the factory with silicon oil. Weighing can be done more rapidly on torsion balances with damping devices than on those lacking them.

There is usually a means by which the torsion balance can be arrested. This need only be done when the balance is to be moved to a new location or otherwise transported.

The sensitivity of the torsion balance varies with the model chosen. For most clinical laboratories, however, balances with a sensitivity of readings to the nearest 0.01 g are satisfactory. The manufacturer supplies a complete manual with directions for setting up, proper use, and care of the particular torsion balance. These directions should be followed closely.

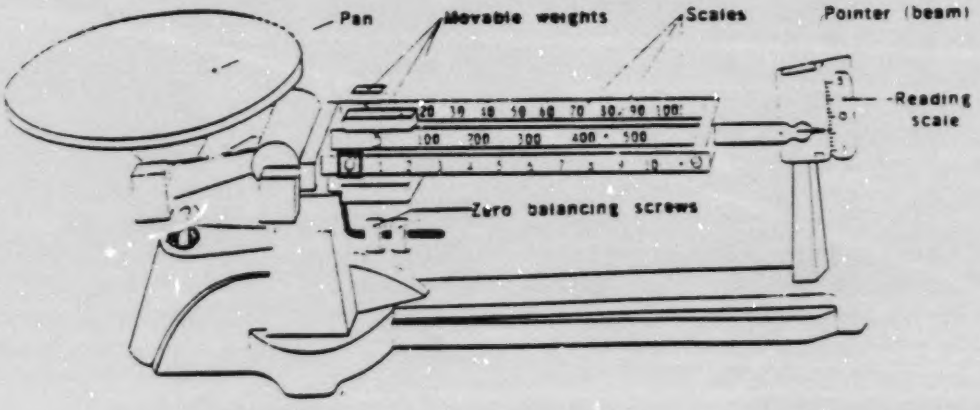
Procedure

1. Check to be sure that the balance is level, and adjust the leveling screws if necessary.
2. Check the zero adjustment. The optical reading scale should read zero with the pan empty and clean; adjust the optical zero with the small control knob if necessary.
3. Place the weighing vessel on the pan. Turn the weight control knob until the optical reading scale reads zero.
4. Add the chemical to the vessel until the desired weight registers on the optical scale. A vernier scale is present on most models so that the weight may be read to the accuracy needed. Torsion balances used in clinical laboratories have an accuracy of either 0.1 or 0.01 g.
5. Remove the vessel with the weighed chemical from the pan. Turn the control knob to zero, and wipe up any spilled chemical immediately.

Triple-beam balance

Another common piece of laboratory apparatus used for weighing is the triple-beam or "trip" balance (Fig. 1-11). This is a less sensitive balance with accuracy to the nearest 0.1 g. Whenever reagents are to be prepared with an accuracy

Fig. 1-11. Triple-beam balance.



of 0.1 g or less, the triple-beam balance can be used most satisfactorily. As the words triple-beam and trip suggest, three beams are present on the balance. Each beam provides a different weighing scale. Scales reading from 0 to 100 g, 0 to 500 g, and 0 to 10 g are usually provided on the triple-beam balance. These scales are provided with movable weights. The two larger scales have weights that lock into accurately milled notches at each calibration to ensure absolute accuracy at each position.

Some models of the triple-beam balance (called the *Harvard triple-beam* balance) have two pans, and some have a single pan. The principle of the weighing process is the same whether there are two pans or only one. Two-pan balances are used when two objects must be balanced against each other, as in balancing tubes for use in the centrifuge. One-pan balances are used a great deal in the laboratory for preparing reagents and chemical solutions.

Some type of less sensitive balance such as the triple-beam or torsion balance is an essential piece of equipment for every clinical laboratory, as many reagents are prepared that do not need the accuracy of the analytical balance. When an accuracy of more than 0.1 g is not needed, the triple-beam balance can be used. It can be operated simply and rapidly and gives accurate weighings when used properly. Even a balance with less sensitivity must be used carefully and according to the directions provided with the particular model.

The triple-beam balance should be placed on a reasonably flat and level surface. The beam should be near zero balance, with all the movable weights at their zero points. A final zero balance is attained by adjusting the balancing screws. It is advisable to check the zero balance periodically, especially if the balance has been moved. If an object is to be weighed, the balance must be set at zero before the weighing is begun. If a vessel is weighed in preparation for the addition of a chemical, it is not necessary to set the balance at the exact zero reading.

Basic parts

1. *Pan.* This is where the object or weighing vessel holding the substance to be weighed is placed.
2. *Beam.* The beam is a lever supported by a knife plane bearing at the center post. The length of beam to the right of the knife plane is graduated for placement of a sliding weight and ends in a pointer. The other end of the beam is attached to the pan guide with a knife edge contact.
3. *Movable weights or poises.* These are sliding weights attached to the beam that are moved to bring the balance into equilibrium. The trip balance has three beams, and various weight increments are added as the poises are advanced toward the pointer ends of the beams.
4. *Reading scale.* This is a scale located at the end of the beam pointer that shows when the balance is in equilibrium.
5. *Balancing screws or spindle.* This is a pair of threaded weights that are used to bring the empty balance into equilibrium.

Procedure for general use

1. Place the weighing vessel on the balance pan without previously bringing the balance to zero.
2. With the weighing vessel on the pan, bring the balance to zero by adjusting the movable weights on the three scales. Record the sum of the weights required for balance.
3. To the recorded weight add the amount of chemical to be weighed. For example, if the reagent to be prepared requires 10.5 g of NaCl and the weighing vessel weighs 35.5 g, the total weight is 46.0 g. Move the movable weights on the scales to give this total weight.
4. Gradually add the chemical until the pointer of the balance rests exactly at the zero mark on the vertical reading scale. Remove the weighing vessel and return the movable weights to their zero positions. Transfer the chemical quantitatively to the flask for dilution.

5. Wipe up any spilled chemical immediately from the balance area.

A special type of triple-beam balance is known as the *Cent-O-Gram* balance. This balance also has three beams, but they are tiered on three levels, so that the readings can be obtained from a single eye level. The three beams on the Cent-O-Gram balance provide different weighing scales. The center beam is graduated to 10 g in 1-g notches. As the name implies, the sensitivity of this balance is the nearest 0.01 g. The Cent-O-Gram balance has a lever for arresting the balance when placing objects on the pan.

On any type of triple-beam balance, the balance position of an object on the pan can be determined by observing the swing of the pointer. A swing of an equal number of divisions on either side of the zero mark on the dial indicates that the scale is balanced. It is not necessary to wait for the oscillation to stop to determine the correct weight. This observation enables the weighing process to be a simple and rapid one.

JOB SHEET

002E-001-001

"REVIEW TYPES OF BALANCES AND THEIR USES"

SELECT THE BEST ANSWER.

1. The "backbone" of the clinical chemistry laboratory is the:

   A. triple-beam balance.
   B. torsion balance.
   C. weighing balance.
   D. analytical balance.

2. _____ are used to weigh the chemicals and to prepare the many chemical solutions needed in the laboratory.

   A. Scales
   B. Balances
   C. Cent-o-grams
   D. Weights

3. _____ balances are used to weigh small amounts of substances with a high degree of accuracy, but just how this is accomplished differs slightly from one balance to another.

   A. Triple-beam
   B. Cent-o-gram
   C. Torsion
   D. Analytical

4. Standard solutions are always very accurately prepared and the _____ balance is used to weigh the chemicals for these solutions.

   A. analytical
   B. triple-beam
   C. torsion
   D. cent-o-gram

5. The analytical balance should be cleaned and adjusted at least _____ _____ to ensure its continued accuracy and sensitivity.

   A. once a week
   B. once a month
   C. once every 6 months
   D. once a year

6. In the manual balance the weights are actually placed on one of the balance pans by _____, and in the automatic balance the weights are added by manipulating a series of _____.

   A. knife edges, screws.
   B. hand, dials.
   C. dials, hands.
   D. beams, dials.

7. Before doing any weighing on the balance, it must be properly

   A. leveled.
   B. controlled.
   C. handled.
   D. understood.

8. In the manually operated analytical balance, there are two pans: the _____ are placed on the right-hand pan, and the _____ to be weighed is placed on the left-hand pan.

   A. object, weights
   B. weights, object
   C. solutions, substances
   D. substances, solutions

9. In the manual balance, the weights are never handled with the fingers but are removed from the box and placed on the balance pan by using ivory-tipped _____.

   A. applicators.
   B. forceps.
   C. handles.
   D. knives.

10. Any air currents present would affect the _____ process.

    A. balancing
    B. adjusting
    C. leveling
    D. weighing

11. To adjust a manual analytical balance to a beginning reading of zero, lower the beam and release the pan arrests, making certain that the chain reading scale and the vernier scale are both set at _____.

    A. 0.
    B. 0.1 mg.
    C. 10 mg.
    D. 20 mg.

12. _____ balances are used mainly for weighing chemicals in the laboratory.

A. Triple-beam
B. Torsion
C. Analytical
D. Cent-o-gram

13. Whenever reagents are to be prepared with an accuracy of 0.1 g or less, the _____ balance can be used most satisfactorily.

A. triple-beam
B. torsion
C. analytical
D. cent-o-gram

14. This balance has three beams tiered on three levels so that the readings can be obtained from a single eye level.

A. Cent-o-gram
B. Triple-beam
C. Torsion
D. Analytical

15. This is the small scale on an analytical balance which is used to obtain precise readings to the nearest 0.1 mg.

A. Reading
B. Vernier
C. Zero
D. Chain

INTERMEDIATE OBJECTIVE #2

DEMONSTRATE USE OF BALANCES.

LEARNING STEPS (Activities)

1. Observe Resource #1 for a demonstration on use of balances.
2. Complete Resource #2 for practice using balances.
3. When you feel you have mastered this task, complete Resource #3 for a final performance.
4. Complete Resource #4 for a written evaluation.
5. Proceed to Resource #5.

RESOURCES

1. See instructor.
2. Job Sheet 002E-002-001, "Practice Using Balances," Pages 16 & 17, in this SLG.
3. Performance Checklist #002E pg. 18, in this SLG.

   See instructor for evaluation.
4. Written Criterion Exam #002E, in the LRC.

   See LRC Secretary.

   See instructor for evaluation.
5. See instructor for next learning guide.

JOB SHEET

002E-002-001

"PRACTICE USING BALANCES"

DIRECTIONS TO THE STUDENT:

GIVEN THE NECESSARY SUPPLIES AND EQUIPMENT, PRACTICE USING BALANCES.

NECESSARY SUPPLIES AND EQUIPMENT:
- Analytical balance
- Triple-beam balance
- Weighing vessel
- Tongs
- Chemical
- Flask

PROCEDURE:

AUTOMATIC ANALYTICAL BALANCE

1. Level balance.
2. Check zero point adjustment.
3. Arrest the balance.
4. Place weighing vessel on the pan.
5. Close the balance window.
6. Weigh the vessel.
7. Read the result.
8. Arrest the balance.
9. Unload the pan.
10. Bring all knobs back to zero.
11. Add total weight.
12. Add slowly, chemical to vessel.
13. Arrest the balance.
14. Unload the pan.
15. Bring knobs back to zero.
16. Clean up.

TRIPLE-BEAM BALANCE

1. Place weighing vessel on balance pan.
2. Bring balance to zero.
3. Record the sum of weights.
4. Add amount of chemical to be weighed.
5. Obtain total weight.
6. Add chemical until at zero mark.
7. Transfer chemical to flask.
8. Clean up.

PERFORMANCE/PRODUCT CHECKLIST

Program: MEDICAL ASSISTING

Task No: 002E

Student's Name: _____ Date Of Attempt: _____

Evaluator's Name: _____ Evaluation Site: _____

Performance Attempt: 1 2 3 4

Terminal Performance Objective:

Given the necessary tools and equipment, demonstrate use of balances.

Directions To The Student:

Before attempting this task for mastery, carefully review this checklist. You will be evaluated on the basis of this checklist. When you feel you are ready for evaluation, contact your instructor. You must complete your performance within 10 minutes and must score at least 24 out of 24 points or 100 % for mastery. Critical items are marked with an asterisk (*). These items must be satisfactorily completed.

Directions To The Evaluator:

The student will contact you when ready for the evaluation. The student must complete the performance within 10 minutes and must score 24 out of 24 points or 100 % and all items marked with an asterisk (*) must be satisfactorily completed.

CRITICAL ITEMS	ITEMS TO BE OBSERVED OR CHECKED	RATING YES	RATING NO
	AUTOMATIC ANALYTICAL BALANCE		
*	1. Level balance.		
*	2. Check zero point adjustment.		
*	3. Arrest the balance.		
*	4. Place weighing vessel on the pan.		
*	5. Close the balance window.		
**	6. Weigh the vessel.		
*	7. Read the result.		
*	8. Arrest the balance.		
*	9. Unload the pan.		
*	10. Bring all knobs back to zero.		
*	11. Add total weight.		
*	12. Add slowly, chemical to vessel.		
*	13. Arrest the balance.		
*	14. Unload the pan.		
*	15. Bring knobs back to zero.		
*	16. Clean up.		
	TRIPLE-BEAM BALANCE		
*	17. Place weighing vessel on balance pan.		
*	18. Bring balance to zero.		
*	19. Record the sum of weights.		
*	20. Add amount of chemical to be weighed.		

SEE NEXT PAGE

TOTAL POINTS EARNED =

POINTS NEEDED FOR MASTERY =
TOTAL POINTS POSSIBLE =

CRITICAL ITEMS	ITEMS TO BE OBSERVED OR CHECKED	RATING YES	RATING NO
*	21. Obtain total weight.		
*	22. Add chemical until at zero mark.		
*	23. Transfer chemical to flask.		
*	24. Clean up.		

TOTAL POINTS EARNED =

POINTS NEEDED FOR MASTERY = 24
TOTAL POINTS POSSIBLE = 24

PROGRAM MEDICAL ASSISTING

CRITERION EXAM

TASK = 002E

DIRECTIONS:

THE PURPOSE OF THIS EXAM IS TO DETERMINE WHETHER OR NOT YOU HAVE UNDERSTOOD THE INFORMATION ON DEMONSTRATING USE OF BALANCES.

Each of the questions or incomplete statements below is followed by several words, phrases, or a series of numbers. Choose the one which best answers the question or completes the statement correctly. Place the letter associated with that choice (A,B,C or D) in the numbered blank space on your ANSWER SHEET. DO NOT WRITE ON THIS TEST!!! To master this exam you must answer 14 out of 15 items correctly, 90 %.

EVALUATION SHEET

WRITTEN CRITERION EXAMINATION

TASK #002E

"DEMONSTRATE USE OF BALANCES"

1. Standard solutions are always very accurately prepared and the _____ balance is used to weigh the chemicals for these solutions.

   A. analytical
   B. triple-beam
   C. torsion
   D. cent-o-gram

2. In the manual balance, the weights are never handled with the fingers, but are removed from the box and placed on the balance pan by using ivory-tipped _____.

   A. applicators.
   B. forceps.
   C. handles.
   D. knives.

3. This is the small scale on an analytical balance which is used to obtain precise readings to the nearest 0.1 mg.

   A. Reading
   B. Vernier
   C. Zero
   D. Chain

4. The "backbone" of the clinical chemistry laboratory is the _____ _____.

   A. triple-beam balance.
   B. torsion balance.
   C. weighing balance.
   D. analytical balance.

5. Before doing any weighing on the balance, it must be properly _____.

   A. leveled.
   B. controlled.
   C. handled.
   D. understood.

6. This balance has three beams tiered on three levels so that the readings can be obtained from a single eye level.

   A. Cent-o-gram
   B. Triple-beam
   C. Torsion
   D. Analytical

7. Any air currents present would affect the _____ process.

   A. balancing
   B. adjusting
   C. leveling
   D. weighing

8. _____ balances are used to weigh small amounts of substances with a high degree of accuracy, but just how this is accomplished differs slightly from one balance to another.

   A. Triple-beam
   B. Cent-o-gram
   C. Torsion
   D. Analytical

9. To adjust a manual analytical balance to a beginning reading of zero, lower the beam and release the pan arrests, making certain that the chain reading scale and the vernier scale are both set at _____.

   A. 0.
   B. 0.1 mg.
   C. 10 mg.
   D. 20 mg.

10. In the manually operated analytical balance, there are two pans: the _____ are placed on the right-hand pan, and the _____ to be weighed is placed on the left-hand pan.

   A. object, weights
   B. weights, object
   C. solutions, substances
   D. substances, solutions

11. _____ balances are used mainly for weighing chemicals in the laboratory.

   A. Triple-beam
   B. Torsion
   C. Analytical
   C. Cent-o-gram

12. _____ are used to weigh the chemicals and to prepare the many chemical solutions needed in the laboratory.

A. Scales
B. Balances
C. Cent-o-gram
D. Weights

13. The analytical balance should be cleaned and adjusted at least _____ _____ to ensure its continued accuracy and sensitivity.

A. once a week
B. once a month
C. once every 6 months
D. once a year

14. Whenever reagents are to be prepared with an accuracy of 0.1 g or less, the _____ balance can be used most satisfactorily.

A. triple-beam
B. torsion
C. analytical
D. cent-o-gram

15. In the manual balance the weights are actually placed on one of the balance pans by _____ and in the automatic balance the weights are added by manipulating a series of _____.

A. knife edges, screws.
B. hand, dials.
C. dials, hands.
D. beams, dials.

100% IS FOR YOU!

LAKE COUNTY AREA VOCATIONAL CENTER

COMPETENCY-BASED INDIVIDUALIZED VOCATIONAL EDUCATION INSTRUCTION

STUDENT LEARNING GUIDE

Produced By Rosemarie Meyer Date 12/84

* TASK: PERFORM PIPETTING.

*High Tech

PURPOSE: Glassware is used in all departments of the laboratory, and special types of glass apparatus have been devised for special uses. One special type of glassware (volumetric glassware) is pipets. This Learning Guide will assist you to perform pipetting.

Medical Assisting

emf

Program	Task	Est.Time	Prereq.
07.0904	003	8 hrs.	

LEARNING CONTRACT (optional)

1. STUDENT DATA

NAME _____ SOCIAL SECURITY NUMBER _____

LENGTH OF CONTRACT (NORMAL TIME IN HOURS) 8 hrs.

2. TERMINAL PERFORMANCE OBJECTIVE

Given the necessary tools and equipment, perform pipetting. To master this task you must score 4 out of 4 (100%) on a final performance and 19 out of 20 (95%) on a Written Criterion Examination.

2a. INTERMEDIATE OBJECTIVE(s)

1. Describe pipets.
2. Perform pipetting.

3. AGREEMENT

I, _____ agree to complete the above stated terminal performance requirement within _____ to _____ I further recognize that the conditions of the contract (performance and time agreement) report my ability to perform the requirements of the occupation and record my progress.

_____ Student's Signature

_____ Instructor's Signature (verifies competency)

Program	Task	Page
07.0904	003	2

INTERMEDIATE OBJECTIVE #1

DESCRIBE PIPETS.

LEARNING STEPS (Activities)

1. Read Resource #1 for information on pipets.

2. Complete Resource #2 for a review on pipets.

3. Proceed to Resource #3.

RESOURCES

1. Information Sheet 003-001-001, "Pipets," Pg. 4-10, in this SLG.

   Information taken from Basic Techniques for the Medical Laboratory by Jorgenson and Ringsrud.

2. Job Sheet 003-001-001, "Review Pipets," pg. 11-14 in this SLG.

   See instructor for evaluation.

3. IO #2, pg. 15 , in this SLG.

Volumetric glassware

Volumetric glassware must go through a rigorous process of volume calibration to ensure the accuracy of the measurements required for laboratory determinations. In very precise work it is never safe to assume that the volume contained or delivered by any piece of equipment is exactly that indicated on the equipment. The calibration process is lengthy and time-consuming; therefore the cost of volumetric glassware is relatively high compared with the cost of noncalibrated glassware (beakers, test tubes, etc.).

Volumetric flasks

Volumetric flasks are flasks with a round bulb at the bottom. This tapers to a long neck, on which the calibration mark is found. The specifications set up by the National Bureau of Standards apply to all volumetric glassware and therefore to volumetric flasks (Fig. 1-3).[7] Volumetric flasks are calibrated to contain a specific amount or volume of liquid, and therefore the letters T.C. are inscribed somewhere on the neck of the flask. There are many different sizes of volumetric flasks, for the different volumes of liquid that are used. The following are some of the sizes in which volumetric flasks can be purchased: 10, 25, 50, 100, and 500 ml, and 1 and 2 L.

Volumetric flasks have been calibrated individually to contain the specified volume. For each size of volumetric flask there are certain allowable limits within which its volume must lie. This is called the *tolerance* of the flask. All volumetric glassware has a specific tolerance, the capacity tolerance, which is dependent on the size of the glassware. For example, a 100-ml volumetric flask has a tolerance of ±0.08 ml. Conditions are controlled during the calibration of a 100-ml volumetric flask to guarantee these limits. A tolerance of ±0.08 indicates that the allowable limits for the volume of a 100-ml volumetric flask are from 99.92 to 100.08 ml. A tolerance of ±0.05 ml for a 50-ml volumetric flask indicates allowable limits ranging from 49.95 to 50.05 ml for the volume of the flask. Volumetric flasks are used in the preparation of specific volumes of reagents or laboratory solutions. They should be used with reagents or solutions at room temperature. Solutions diluted in volumetric flasks should be repeatedly mixed during the dilution so that the contents are homogeneous before they are made up to volume. In this way, errors due to the expansion or contraction of liquids during mixing are made negligible. An important factor in the use of any volumetric apparatus is an accurate reading of the meniscus level. For more information on reading a meniscus, see under General Considerations in Pipetting.

Graduated measuring cylinders

A graduated measuring cylinder is a long cylindrical piece of glassware with calibrated markings on it. Graduated cylinders are used to measure volumes of liquids when a high degree of accuracy is not essential. They can be made from plastic or polyethylene as well as from glass (Fig. 1-3). Graduated cylinders come in various sizes according to the volumes they measure: 10, 25, 50, 100, 500, and 1000 ml. A 100-ml graduated cylinder can measure 100 ml or a fraction thereof, depending on the calibration, or graduation, marks on it. Most graduated cylinders are calibrated to deliver. This will be indicated directly on the glassware by the inscription T.D. The letters T.D. can be found on many kinds of volumetric glassware, especially on the numerous kinds of pipets used in the laboratory (see under Pipets).

Graduated cylinders can be used to measure a specified volume of a liquid, such as water, in the preparation of laboratory reagents. The calibration marks on the cylinder indicate its capacity at different points. If 450 ml of water is to be measured, the most satisfactory cylinder to use would be one with a capacity of 500 ml. Graduated cylinders are not calibrated as accu-

rately as volumetric flasks. Therefore, the capacity tolerance for graduated cylinders allows a greater variation in volume. The capacity tolerance is greater for the larger graduated cylinders. A 100-ml graduated cylinder (T.D.) has a tolerance of ±0.40 ml, meaning that the allowable limits are from 99.60 to 100.40 ml.

Pipets

Pipets are another type of volumetric glassware used extensively in the laboratory. Many types of pipets are available. It is important, however, to use only pipets manufactured by reputable companies. Care and discretion should be used in selecting pipets for clinical laboratory use, since their accuracy is one of the determining factors in the accuracy of the procedures carried out. A pipet is a cylindrical glass tube used in measuring fluids. It is calibrated to deliver, or transfer, a specified volume from one vessel to another (Fig. 1-3).

Each pipet has at least one calibration or graduation mark on it, as does all volumetric glassware. A pipet is filled by using mechanical suction or an aspirator bulb. Mouth suction is never used. Strong acids, bases, solvents, or human specimens are much too potent or contaminated to risk pipetting them by mouth. Caustic liquids and some solvents are very dangerous: some destroy tissue immediately on contact. Some solvents have harmful vapors (see under Safety in the Laboratory).

For most general laboratory use, there are two main types of pipets, the volumetric (or transfer) pipet and the graduated (or measuring) pipet. They are classified according to whether they contain or deliver a specified amount. For this reason, they may be called *to-contain* or *to-deliver* pipets. A to-contain pipet is identified by inscribed letters T.C. and a to-deliver one by the letters T.D. The T.D. pipet is filled properly and allowed to drain completely into a receiving vessel. Portions of nonviscous samples, such as filtrates, serum, and standard solutions, are accurately measured by allowing the volumetric pipet to drain while it is held in the vertical position and by using only the force of gravity (see under General Pipetting Procedure). For most volumetric glassware the temperature of calibration is usually 20°C, and this is inscribed on the pipet (see under Calibration of Volumetric Glassware).

The opening (orifice) at the delivery tip of the pipet is of a certain size to give a specified length of time for drainage when the pipet is held vertically. A pipet must be held vertically to ensure proper drainage. It will not drain as fast when held at a 45° angle. The actual procedure is discussed further under Pipetting (see Pipetting Technique).

Volumetric pipets

A pipet that has been calibrated to deliver a fixed volume of liquid by drainage is known as a *volumetric* pipet, or *transfer* pipet. These pipets consist of a cylindrical bulb joined at both ends to narrow glass tubing. A calibration mark is etched around the upper suction tube, and the lower delivery tube is drawn out to a fine tip. Some important considerations concerning volumetric pipets are that the calibration mark should not be too close to the top of the suction tube, the bulb should merge gradually into the lower delivery tube, and the delivery tip should have a gradual taper. To reduce drainage errors, the orifice should be of such a size that the flow out of the pipet is not too rapid. These pipets should be made from a good-quality glass, such as Kimax or Pyrex (Fig. 1-4).

Volumetric pipets are suitable for all accurate measurements of volumes of 1 ml or more. They are calibrated to deliver the amount inscribed on them. This volume is measured from the calibration mark to the tip. A 5-ml volumetric pipet will deliver a single measured volume of 5 ml, and a 2-ml volumetric pipet will deliver 2 ml. The tolerance of volumetric pipets increases with the capacity of the pipet. A 10-ml volumetric pipet will have a greater tolerance than a 2-ml

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"PIPETS" (Cont'd)

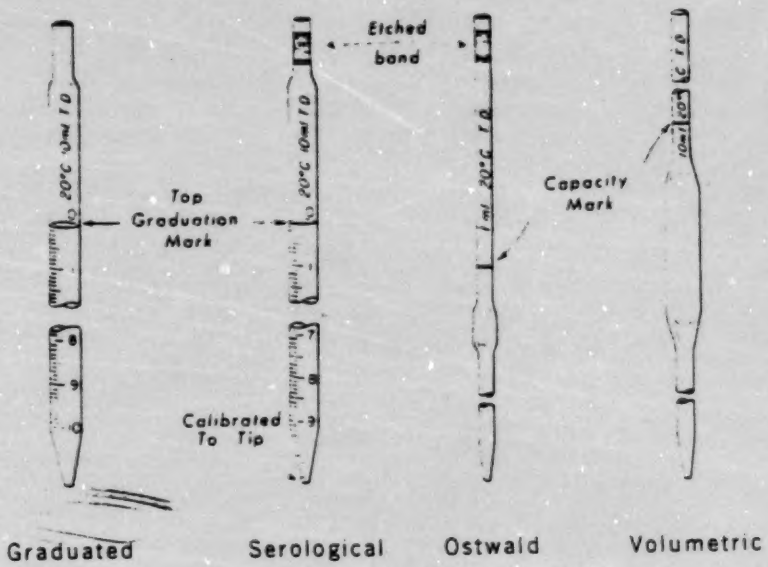

Fig. 1-4. Types of pipets.

one. The tolerance for a 5-ml volumetric pipet is ±0.01 ml. When volumes of liquids are to be delivered with great accuracy, a volumetric pipet is used. Volumetric pipets are used to measure standard solutions, unknown blood and plasma filtrates, serum, plasma, urine, spinal fluid, and some reagents.

Measurements with volumetric pipets are done individually, and the volumes can only be whole milliliters (e.g., 1, 2, 5, and 10 ml). To transfer 1 ml of a standard solution into a test tube volumetrically, a 1-ml volumetric pipet is used. To transfer 5 ml of the same solution, a 5-ml volumetric pipet is used. After a volumetric pipet drains, a drop remains inside the delivery tip. This drop is *not* to be blown out: the specific volume the pipet is calibrated to deliver is dependent on the fact that the drop is left in the tip of the pipet. Information inscribed on the pipet includes the temperature of calibration (usually 20°C), capacity, manufacturer, and usage (T.D.). The technique involved in using volumetric pipets correctly is very important, and a certain amount of skill is required (see under Pipetting Technique).

Graduated pipets

Another way to deliver a particular amount of liquid is to deliver that amount of liquid contained between two calibration marks on a cylindrical tube, or pipet. Such a pipet is called a *graduated*, or *measuring*, pipet. It has several graduation, or calibration, marks (Fig. 1-4). Many measurements in the laboratory do not require the precision of the volumetric pipet. Graduated pipets are used when great accuracy is not required. This does not mean that these pipets may be used with less care than the volumetric pipets. Graduated pipets are used primarily in measuring reagents, but they are not calibrated with sufficient tolerance to use in measuring standard or control solutions, unknown specimens, or filtrates.

A graduated pipet is a straight piece of glass tubing with a tapered end and graduation marks

on the stem separating it into parts. Depending on the size used, graduated pipets can be used to measure parts of a milliliter or many milliliters. These pipets come in various sizes or capacities, including 0.1, 0.2, 1, 2, 5, 10, and 25 ml. If 4 ml of deionized water is to be measured into a test tube, a 5-ml graduated pipet would be the best choice. Since graduated pipets require draining between two marks, they introduce one more source of error, compared with the volumetric pipets with only one calibration mark. This makes measurements with the graduated pipet less precise. Because of this relatively poor precision, the graduated pipet is used where speed is more important than precision. It is used for measurements of reagents and is generally not considered accurate enough for measuring samples and standard solutions.

Two types of pipets are calibrated for delivery (Fig. 1-4). One (called a Mohr pipet) is calibrated between two marks on the stem, and the other (a serological pipet) has graduation marks down to the delivery tip. The serological pipet has a larger orifice and therefore drains faster than the Mohr pipet (see under Serological Pipets).

The volume of the space between the last calibration mark and the delivery tip is not known in the Mohr pipet. In graduated pipets, this space cannot be used for measuring fluids. Graduated pipets are calibrated in much the same manner as volumetric pipets; however, they are not constructed with as strict specifications and they have larger capacity tolerances. The allowable tolerance for a 5-ml graduated pipet is ±0.02 ml.

To-contain pipets (micropipets)

The to-contain pipet, when used properly, is one of the more precise pipets used in the clinical laboratory. This type of pipet is calibrated to *contain* a specified amount of liquid. If a pipet contains only 0.1 ml, and 0.1 ml of blood is needed for a chemistry determination, then none of the blood can be left inside the pipet. The entire contents of the pipet must be emptied. If this pipet is *rinsed well* with a diluting solution, then all the blood or similar specimen will be removed from it. The correct way to use a to-contain pipet is to rinse it with a suitable diluent. Thus, a to-contain pipet cannot be used properly unless the receiving vessel contains a diluent; that is, a to-contain pipet should not be used to deliver a specimen into an empty receiving vessel. Since all the liquid in a to-contain pipet is rinsed out and used, there is only one graduation mark.

To-contain pipets are used when micro amounts of blood or specimen are needed, and they are also called *micropipets* in many areas of the laboratory. Many procedures require only a small amount of blood, and a micropipet is used for this measurement. Because even a minute volume remaining in the pipet can cause a significant error in micro work, most micropipets are calibrated to contain (T.C.) the stated volume rather than to deliver it. They are generally available in small sizes, such as 20, 50, 100, and 200 µl. A common micropipet used is the Sahli hemoglobin pipet, calibrated to contain 0.02 ml or 20 µl.

A special disposable micropipet used in the hematology laboratory is a self-filling pipet accompanied by a polyethylene reagent reservoir (see under Hematology). This unit is called a Unopette (Becton, Dickinson & Co., Rutherford, N.J.) and is used by many laboratories. A glass capillary pipet is fitted in a plastic holder and fills automatically with blood by means of capillary action. The plastic reagent bottle (called the reservoir) is squeezed slightly while the pipet is inserted. On release of pressure, the sample is drawn into the diluent in the reservoir. Intermittent squeezing fills and empties the pipet to rinse out the contents of the pipet. This type of unit has been adapted for several chemical and hematological determinations.

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Ostwald pipets

A special type of pipet designed for use in measuring viscous fluids such as blood or serum is known as the *Ostwald* pipet (or the *Ostwald-Folin* pipet). When blood is to be measured in the chemistry laboratory, the Ostwald pipet is used. This pipet is similar in appearance to the volumetric pipet, except that the bulb is closer to the delivery tip (Fig. 1-4). Ostwald pipets are usually calibrated to be blown out, and therefore an etched ring or band will be seen near the suction hole. To minimize the effects of viscosity, the Ostwald pipet is designed with a large oval bulb and a short delivery tip.

Ostwald pipets come in several sizes; the most common ones are 0.5, 1, and 2 ml. When using an Ostwald pipet to measure blood, the blood should be allowed to drain as slowly as possible so that no residual film is left on the sides of the pipet. Contrary to the usual practice of reading the bottom of the meniscus for liquids being measured by pipet, when blood is pipetted in the Ostwald pipet, the top of the meniscus is read (blood is not transparent and the bottom of the meniscus cannot be seen clearly).

Serological pipets

Another pipet used in the laboratory, but not often in the chemistry laboratory, is called a *serological* pipet. It is much like the graduated pipet in appearance (Fig. 1-4). The orifice, or tip opening, is larger in the serological pipet than in other pipets. The rate of fall of liquid is much too fast for great accuracy or precision. For use in chemistry it would be necessary to retard the flow of liquid from the delivery tip of the serological pipet. The serological pipet is graduated to the end of the delivery tip and has an etched band on the suction piece. It is therefore designed to be blown out. The serological pipet is less precise than any of the pipets discussed above. It is designed for use in serology, where relative values are sought. It is best not to use the serological pipet for chemistry.

Stopcock pipets

The *stopcock* pipet is designed for delivering blood into a Van Slyke machine, which is used for the determination and analysis of gases such as oxygen and carbon dioxide. The stopcock pipet can be used to deliver anything that is not to be exposed to the air. It resembles a small volumetric pipet with a stopcock attached near the delivery tip; this is used for better control of the delivery of the sample into the machine. Stopcock pipets have two calibration marks, one on either side of the bulb.

Automatic pipets

Automatic and semiautomatic versions of pipets are useful in many areas of laboratory work. Use of automatic pipetting devices eliminates pipet cleaning and reduces the error resulting from the variation in pipetting techniques. Several different types are available, and each must be carefully calibrated before it is used. The problems encountered with automatic pipetting devices depend to a large degree on the nature of the solution being pipetted. Some reagents cause more bubbles than others, and some are more viscous. Each of these tendencies can cause problems with the measurement and delivery of samples and solutions.

Automatic pipetting devices permit measuring out a whole series of equal volumes. They provide very efficient delivery of equal volumes of specimens followed by equivalent volumes of diluent. These automatic devices can be operated either manually or by a motor. Since proper care and calibration are essential for accurate sampling, it is important to read and follow the manufacturer's instructions.

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"PIPETS" (Cont'd)

under Safety in the Laboratory). The pipets are allowed to soak in the cleaning solution for 30 minutes.

The next step involves thorough rinsing of the pipets. This can be accomplished by hand, but more often it is done with the aid of an automatic pipet washer. The pipets are rinsed with tap water, utilizing the automatic pipet washer, for 1-2 hours. They are then rinsed in deionized or distilled water two or three times and dried in a hot oven. An alternative cleaning solution is a solution of detergent. However, the acid cleaning solution is recommended.

Cleaning diluting pipets

Pipets used in the hematology laboratory for dilution are also cleaned in a special way. They should always be rinsed immediately after use, preferably by being placed in a tumbler or beaker of water until they are cleaned. There are several ways to clean these pipets, but in general they are first cleaned with tap water, then with distilled water, and finally rinsed with either alcohol or acetone. Acetone assists in drying the inside of the pipet. Usually the cleaning is done with suction, using a special pipet holder that fits onto the suction apparatus. The pipets are also dried with suction. Periodically, the pipets should be cleaned with a detergent solution, rinsed well, and dried.

Cleaning photometry cuvettes

Cuvettes must be scrupulously clean and free from grease smudges or scratches. As soon as possible after use, cuvettes should be rinsed with tap water, filled with a mild detergent solution, and placed in a rubberized test tube rack. It is best not to put them into a regular dishwashing basket where they would rub against each other and be scratched. After standing with the detergent solution, the cuvettes are rinsed several times with tap water and two or three times with distilled or deionized water. When drying cuvettes, high temperatures and unclean air should be avoided. A low to medium oven (not above 100°C) can be used for rapid drying. In some laboratories, there are special dishwashing machines that can adequately handle cuvettes.

Glass breakage and replacement

It is important in the clinical laboratory to check all glassware periodically to determine its condition. No broken or chipped glassware should be used. Many laboratory accidents are caused by the use of broken glassware. Serious cuts may result, and infections may set in.

Each time a laboratory procedure is carried out, the glassware used should be checked; equipment such as beakers, pipets, test tubes, and flasks should not have broken edges or cracks. To prevent breakage, glassware should be handled carefully; carrying too much glassware at one time from one place to another in the laboratory is to be avoided.

When glassware is broken, it must be replaced with another like piece. Breakage should be reported to an instructor or department head, so that replacement can be arranged. Several laboratory equipment catalogs are available from which the required items may be ordered. These catalogs are distributed by supply companies that handle laboratory equipment. They describe the quality, capacity, tolerance, and cost of the available items. To purchase equipment at the most reasonable price it is advisable to compare specific items in several different catalogs.

THE MICROSCOPE

The microscope is probably the piece of equipment that receives the most use (and, unfortunately, misuse) in the clinical laboratory. Microscopy is a basic part of the work in many areas

soap, detergent, or cleaning powder. In most laboratories, detergents are used. If the dirty glassware has been soaking in a solution of the detergent water, the cleaning job will be much easier.

General cleaning procedure

There are various specific methods of cleaning laboratory glassware. Most glassware (with the exception of pipets) can be cleaned in the following way.

1. Put the specified amount of detergent into a dishpan or washing bucket containing moderately hot water. Allow the detergent to dissolve thoroughly.

2. Rinse glassware (or other items that can be washed) in tap water before placing it in the detergent solution. Never allow dirty glassware to dry out; always place it in a soaking bucket. Glassware should be completely submerged in the bucket or pan. Fill large pieces with detergent water and set aside to soak. Soaking glassware for at least 1 hour before washing makes the washing procedure much more efficient.

3. Using a cleaning brush, thoroughly scrub the glassware, being certain to clean all parts. Brushes of various sizes should be available to fit the different-sized test tubes, flasks, funnels, and bottles. Excessive brushing and improper use of brushes may cause scratching of the glassware. Avoid the use of abrasive cleaners on glassware.

4. Rinse glassware under running tap water; allow the water to run into each piece of glassware, pour it out, and repeat several times (7-10 times is sufficient). Rinse the outside of the glassware too. It is especially important to *remove all the detergent from the glassware before use*: if detergent remains, the alkali in it may interfere with laboratory determinations.

5. After thoroughly rinsing the glassware with tap water, rinse it with distilled or deionized water about three times. Certain glassware used for microbiological studies requires even longer rinsing with deionized water. Use deionized or distilled water in the final rinsing of all laboratory glassware.

6. Glassware may be dried in a hot oven (no hotter than 100°C) or at room temperature. If a higher temperature is used, the glassware can become distorted. Always dry glassware or other equipment in an inverted position to ensure complete drainage of water as it dries. Never dry laboratory ware with a towel. Do not dry plasticware or rubber items in an oven.

7. Check the glassware for cleanliness by observing the water drainage. Chemically clean glassware will drain uniformly; dirty glassware will drain leaving water droplets adhering to the walls of the glass.

Clearing pipets

Pipets used in the laboratory are cleaned in a special way. Immediately after use, the pipets should be placed in a special pipet container or cylinder containing water; the water should be high enough to completely cover the pipets. Pipets should be carefully placed in the container to avoid breakage. When the pipets are to be cleaned, they are removed from the cylinder and placed in another cylinder containing an acid cleaning solution. This cleaning solution is usually a combination of sulfuric acid and either potassium or sodium dichromate (called acid-dichromate solution). Acid-dichromate cleaning solution may be purchased commercially, or it may be prepared by dissolving 100 g of sodium or potassium dichromate in 100 ml of water and slowly adding, while stirring, the contents of one bottle of concentrated or technical grade sulfuric acid. For safe handling during the preparation, the concentrated acid solution should be placed in a pan of cold water because of the great amount of heat generated on mixing the acid and water. Safety goggles should always be worn during the preparation of this solution, as should rubber gloves and a protective apron. It is an extremely potent solution, and it must be handled cautiously or serious burns will result (see

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JOB SHEET 003-001-001

"REVIEW PIPETS"

SELECT THE BEST ANSWER.

1. A cylindrical glass tube used in measuring fluids and calibrated to deliver, or transfer, a specified volume from one vessel to another is a _____.

   A. pipet
   B. flask
   C. cylinder
   D. buret

2. A _____ is filled by using mechanical suction or an aspirator bulb.

   A. pipet
   B. flask
   C. cylinder
   D. buret

3. _____ suction is never used because strong acids, bases, solvents, or human specimens are too potent or contaminated to pipet by mouth.

   A. Mechanical
   B. Bulb
   C. Mouth
   D. Automatic

4. For most general laboratory use, there are two main types of pipets:

   A. volumetric, graduated.
   B. graduated, volumetric.
   C. micropipets, ostwald.
   D. serological, automatic.

5. A to-contain pipet is identified by inscribed letters _____ and to-deliver one by the letters _____.

   A. T.C., T.D.
   B. T.D., T.C.
   C. V.P., G.P.
   D. G.P., V.P.

6. For most volumetric glassware the temperature of calibration is _____ and this is inscribed on the pipet.

   A. 5°C
   B. 10°C
   C. 20°C
   D. 25°C

7. Volumetric flasks, pipets, graduated cylinders, and burets are examples of _____.

   A. containers.
   B. receivers.
   C. plasticware.
   D. glassware.

8. A pipet must be held _____ to ensure proper drainage.

   A. horizontal
   B. vertical
   C. parallel
   D. diagonal

9. A volumetric pipet calibrated to deliver a fixed volume of liquid by drainage is a _____ pipet.

   A. graduated
   B. transfer
   C. serological
   D. measuring

10. Volumetric pipets are suitable for all accurate measurements of volumes of _____ or more.

    A. 1 ml.
    B. 2 ml.
    C. 5 ml.
    D. 10 ml.

11. A measuring pipet delivers that amount of liquid contained between two calibration marks on a cylindrical tube. This is a _____ pipet.

    A. graduated
    B. serological
    C. volumetric
    D. automatic

12. To-contain, or _____, pipets are used when micro amounts of blood or specimen are needed.

    A. Ostwald
    B. transfer
    C. micro
    D. Mohr

"REVIEW PIPETS" (Cont'd)

13. A special type of pipet designed for use in measuring viscous fluids such as blood or serum is the _____ pipet.

    A. Stopcock
    B. graduated
    C. volumetric
    D. Ostwald

14. Another pipet used in the laboratory for use in serology is _____

    A. serological.
    B. graduated.
    C. volumetric.
    D. measuring.

15. The pipet used for the determination and analysis of gases such as oxygen and carbon dioxide is _____

    A. Ostwald-Folin.
    B. measuring.
    C. Stopcock.
    D. serological.

16. With automatic and semi-automatic versions of pipets it is important to read and follow the manufacturer's instructions and _____ before it is used.

    A. wash
    B. standardize
    C. rinse
    D. calibrate

17. Immediately after use, the pipets should be _____ in an acid-dichromate solution or detergent solution and rinsed well.

    A. washed
    B. cleaned
    C. rinsed
    D. stirred

18. _____ and correct first-aid procedures cannot be over-emphasized to anyone working in the medical laboratory.

    A. Common Sense
    B. OSHA
    C. Labeling
    D. Safety

19. Use caution when _____ any specimen from a patient.

    A. handling
    B. pipetting
    C. preparing
    D. collecting

20. Wear _____ when preparing reagents with strong chemicals such as dichromate acid cleaning solution used to clean laboratory glassware.

    A. sterile gloves
    B. safety goggles
    C. lab apron
    D. lab coat

INTERMEDIATE OBJECTIVE #2

PERFORM PIPETTING.

LEARNING STEPS (Activities)	RESOURCES
1. Observe Resource #1 for a demonstration on pipetting using different types of pipets.	1. See instructor.
2. Complete Resource #2 for identification of pipets.	2. Job Sheet 003-002-002, "Identify Pipets," pg. 16 , in this SLG.
3. Complete Resource #3 for practice on pipetting.	3. Job Sheet 003-002-003, "Pipetting," Pg. 17 , in this SLG.
4. When you feel you have mastered this task, complete Resource #4 for a performance evaluation.	4. Performance checklist Task # 003 "Perform Pipetting," Pg. 19 , in this SLG. See instructor for evaluation.
5. Complete Resource #5 for a written evaluation.	5. Written Criterion Exam, "Perform Pipetting," Task # 003, in the LRC. See LRC Secretary.
6. Proceed to Resource #6 for the next learning guide.	6. See instructor.

JOB SHEET

003-002-002

"IDENTIFY PIPETS"

A. Place one pipet of each kind in the lab on the table.

B. Refer to the Resource information in this learning guide and Scientific Products or Fischer or catalogs as such located in the Medical Assisting Lab.

C. Make a poster pasting pictures of each pipet and giving a full description of each.

D. Laminate for protection.

JOB SHEET

003-002-003

"PIPETTING"

DIRECTIONS TO THE STUDENT:

Given the necessary tools and equipment, perform pipetting.

NECESSARY TOOLS AND EQUIPMENT:

Volumetric Pipet
Graduated Pipet
Serological Pipet
Micropipet

Whole Blood or Water
Test Tubes on Vacutainer
(With Water) (With Whole Blood)
Rack
Suction Bulb

PROCEDURE:

1. Place test tubes upright in a test tube rack on vacutainer tubes.
2. Read procedure manual for individual pipet procedures.
3. Fill the pipet with blood or water (whatever instructor has available).
4. Throw away vacutainer tubes in proper receptacle.
5. Clean test tubes.
6. Clean working area.
7. Wash hands.

PERFORMANCE/PRODUCT CHECKLIST

Program: MEDICAL ASSISTING

Task No: 003

Student's Name: _____ **Date Of Attempt:** _____

Evaluator's Name: _____ **Evaluation Site:** LCAVC

Performance Attempt: 1 2 3 4

Terminal Performance Objective:

GIVEN THE NECESSARY TOOLS AND EQUIPMENT, PERFORM PIPETTING.

Directions To The Student:

Before attempting this task for mastery, carefully review this checklist. You will be evaluated on the basis of this checklist. When you feel you are ready for evaluation, contact your instructor. You must complete your performance within 10 minutes and must score at least 4 out of 4 points or 100 % for mastery. Critical items are marked with an asterisk (*). These items must be satisfactorily completed.

Directions To The Evaluator:

The student will contact you when ready for the evaluation. The student must complete the performance within 10 minutes and must score 4 out of 4 points or 100 % and all items marked with an asterisk (*) must be satisfactorily completed.

CRITICAL ITEMS	ITEMS TO BE OBSERVED OR CHECKED	RATING YES	RATING NO
*	1. Wash hands.		
*	2. Pipet with pipets given to you by your instructor.		
*	3. Clean up working area and test tubes.		
*	4. Store in proper place.		

TOTAL POINTS EARNED =

POINTS NEEDED FOR MASTERY = 4
TOTAL POINTS POSSIBLE = 4

PROGRAM MEDICAL ASSISTING

CRITERION EXAM

TASK = 003

DIRECTIONS:

THE PURPOSE OF THIS EXAM IS TO DETERMINE WHETHER OR NOT YOU HAVE UNDERSTOOD THE INFORMATION ON PIPETTING.

Each of the questions or incomplete statements below is followed by several words, phrases, or a series of numbers. Choose the one which best answers the question or completes the statement correctly. Place the letter associated with that choice (A,B,C or D) in the numbered blank space on your ANSWER SHEET. DO NOT WRITE ON THIS TEST!!! To master this exam you must answer 19 out of 20 items correctly, 95%.

WRITTEN CRITERION EXAMINATION

"PERFORM PIPETTING"

SELECT THE BEST ANSWER.

1. _____ and correct first-aid procedures cannot be over-emphasized to anyone working in the medical laboratory.

   A. Common sense
   B. OSHA
   C. Labeling
   D. Safety

2. A volumetric pipet calibrated to deliver a fixed volume of liquid by drainage is a _____ pipet.

   A. graduated
   B. transfer
   C. serological
   D. measuring

3. A cylindrical glass tube used in measuring fluids and calibrated to deliver, or transfer, a specified volume from one vessel to another is a _____.

   A. pipet
   B. flask
   C. cylinder
   D. buret

4. Wear _____ when preparing reagents with strong chemicals such as dichromate acid cleaning solution used to clean laboratory glassware.

   A. sterile gloves
   B. safety goggles
   C. lab apron
   D. lab coat

5. A to-contain pipet is identified by inscribed letters _____ and to-deliver one by the letters _____.

   A. T.C., T.D.
   B. T.D., T.C.
   C. V.P., G.P.
   D. G.P., V.P.

6. Volumetric flasks, pipets, graduated cylinders, and burets are examples of _____.

   A. containers.
   B. receivers.
   C. plasticware.
   D. glassware.

7. Use caution when _____ any specimen from a patient.

   A. handling
   B. pipetting
   C. preparing
   D. collecting

8. The pipet used for the determination and analysis of gases such as oxygen and carbon dioxide is _____.

   A. Ostwald-Folin.
   B. measuring.
   C. Stopcock.
   D. serological.

9. _____ suction is never used because strong acids, bases, solvents, or human specimens are too potent or contaminated to pipet by mouth.

   A. Mechanical
   B. Bulb
   C. Mouth
   D. Automatic

10. A measuring pipet delivers that amount of liquid contained between two calibration marks on a cylindrical tube. This is a _____ pipet.

    A. graduated
    B. serological
    C. volumetric
    D. automatic.

11. A pipet must be held _____ to ensure proper drainage.

    A. horizontal
    B. vertical
    C. parallel
    D. diagonal

12. Another pipet used in the laboratory for use in serology is _____.

    A. serological.
    B. graduated.
    C. volumetric.
    D. measuring.

WRITTEN CRITERION EXAMINATION (Cont'd)

"PERFORM PIPETTING"

13. A _____ is filled by using mechanical suction or an aspirator bulb.

A. pipet
B. flask
C. cylinder
D. buret

14. Immediately after use, the pipets should be _____ in an acid-dichromate solution or detergent solution and rinsed well.

A. washed
B. cleaned
C. rinsed
D. stirred

15. For most general laboratory use, there are two main types of pipets:

A. volumetric, graduated.
B. graduated, volumetric.
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16. Volumetric pipets are suitable for all accurate measurements of volumes of _____ or more.

A. 1 ml.
B. 2 ml.
C. 5 ml.
D. 10 ml.

17. A special type of pipet designed for use in measuring viscous fluids such as blood or serum is the _____ pipet.

A. Stopcock
B. graduated
C. volumetric
D. Ostwald

18. For most volumetric glassware the temperature of calibration is _____ and this is inscribed on the pipet.

A. 5°C
B. 10°C
C. 20°C
D. 25°C

"PERFORM PIPETTING"

19. To-contain, or _____, pipets are used when micro amounts of blood or specimen are needed.

    A. Ostwald
    B. transfer
    C. micro
    D. Mohr

20. With automatic and semi-automatic versions of pipets, it is important to read and follow the manufacturer's instructions and _____ before it is used.

    A. wash
    B. standardize
    C. rinse
    D. calibrate

LAKE COUNTY AREA VOCATIONAL CENTER

COMPETENCY-BASED INDIVIDUALIZED VOCATIONAL EDUCATION INSTRUCTION

STUDENT LEARNING GUIDE

Produced By Rosemarie Meyer, RN, CMA Date 10/11/84

TASK: OPERATE CENTRIFUGE

PURPOSE: AS A LABORATORY WORKER YOU WILL BE EXPECTED TO KNOW WHY AND HOW TO OPERATE EACH TYPE OF EQUIPMENT IN THE LABORATORY. THIS ENSURES PROPER PROCEDURE AND SAFE OPERATION. THIS LEARNING GUIDE WILL ASSIST YOU IN OPERATING A CENTRIFUGE.

MEDICAL ASSISTING

Program	Task	Est.Time	Prereq.
07.0904	004	4 HRS.	

edk

LEARNING CONTRACT (optional)

1. STUDENT DATA

NAME _____ SOCIAL SECURITY NUMBER _____

4 hours
LENGTH OF CONTRACT (NORMAL TIME IN HOURS) _____

2. TERMINAL PERFORMANCE OBJECTIVE

Given a centrifuge and necessary tools, you will operate a centrifuge. To master this task you must score 5 out of 6 (90%) on a performance checklist and 14 out of 15 (90%) on a written criterion examination.

2a. INTERMEDIATE OBJECTIVE(s)

1. Describe centrifuge.
2. Operate centrifuge.

3. AGREEMENT

I, _____ agree to complete the above stated terminal performance requirement within _____ to _____. I further recognize that the conditions of the contract (performance and time agreement) report my ability to perform the requirements of the occupation and record my progress.

_____ Student's Signature

_____ Instructor's Signature (verifies competency)

Program	Task	Page
07.0904	004	1

INTERMEDIATE OBJECTIVE #1

Describe centrifuge.

LEARNING STEPS (Activities)

1. Read Resource #1 for information on centrifuge.
2. Complete Resource #2 for a review on the centrifuge.
3. Proceed to Resource #3.

RESOURCES

1. Information Sheet 004-001-001, "Use of the Centrifuge", pages 3-7, in this SLG.
2. Job Sheet 004-001-002, "Review Centrifuge", pages 8 - 10 in this LSG.
3. MPO #2, page 11 , in this SLG.

USE OF THE CENTRIFUGE

Taken from textbook:

BASIC TECHNIQUES FOR THE MEDICAL LABORATORY

by: J. Linne and K Ringsrud

CENTRIFUGES

Taken from textbook:

MOSKY'S FUNDAMENTALS OF MEDICAL ASSISTING

by: M. Shea and S. Zakus

USE OF THE CENTRIFUGE

Centrifugation is used in the separation of a solid material from a liquid. It is also used in recovering solid materials from suspensions, as in the microscopic examination of urine. The solid material or sediment packed at the bottom of the centrifuge tube is sometimes called the precipitate, and the liquid or top portion is called the supernatant. Another important use for the centrifuge is in the separation of serum or plasma from cells in blood specimens. The suspended particles, solid material, or blood cells usually collect at the bottom of the centrifuge tube because the particles are heavier than the liquid. Occasionally the particles are lighter than the liquid and will collect on the surface of the liquid when centrifuged. Centrifugation is employed in every department of the clinical laboratory, in chemistry, urinalysis, hematology, and

blood banking, among others. Proper use of the centrifuge is important for anyone engaged in laboratory work.

Centrifuges facilitate the separation of particles in suspension by the application of centrifugal force. Several types of centrifuges will usually be found in the same laboratory, each designed for special uses. There are table-model and floor-model centrifuges, some small and others very large; there are even refrigerated centrifuges for special procedures.

Directions for use of a centrifuge are most frequently given in terms of speed, or revolutions per minute (r/min). A rheostat is used to set the desired speed: the setting on the rheostat dial does not necessarily correspond directly to revolutions per minute. The setting speeds on the rheostat can also change with variations in weight load and general aging of the centrifuge.

The top speed of most conventional centrifuges is about 3000 r/min. The microhematocrit centrifuge used in many hematology laboratories for packing red blood cells attains a speed of about 10 000 r/min.

Two types of centrifuges are used in doing routine laboratory determinations. One is a conventional horizontal centrifuge and the other is an angle head centrifuge. For the horizontal-type centrifuge, the cups holding the tubes of material to be centrifuged occupy a vertical position when the centrifuge is at rest, but assume a horizontal position when the centrifuge revolves. For the angle head centrifuge, the cups are held in a rigid position at a fixed angle. This position makes the process of centrifuging more rapid than it is with the horizontal centrifuge. There is also less chance that the sediment will be disturbed when the centrifuge stops. Both types of centrifuges may be purchased as table or floor models.

The most important rule to remember in using any centrifuge is: *always balance the tubes placed in the centrifuge.* That is, in the centrifuge cup opposite the material to be centrifuged, place a container of equivalent size and shape with an equal volume of liquid of the same specific gravity as the load. For most laboratory determinations, water may be placed in the balance load.

Special centrifuge tubes should be used. These are tubes constructed to withstand the force exerted by the centrifuge. They have thicker glass walls or are made of a stronger, more resistant glass. Some of these tubes are conical, and some have round bottoms. Some are disposable and others must be washed.

Before placing the centrifuge tubes in the cups or holders, check the cups to make certain that the rubber cushions are in place. If some cushions are missing, the centrifuge will not be properly balanced. Without the cushions, the tubes are more likely to break.

Whenever a tube breaks in the centrifuge cup, it is most important that both the cup and the rubber cushion in the cup be cleaned well to prevent further breakage by glass particles left behind.

Covers specially made for the centrifuge should be used except in certain specified instances. Using the cover prevents possible danger from flying glass should tubes break in the centrifuge. Keep the centrifuge cover closed at all times, even when not using the machine. In addition to the danger from broken glass, using the centrifuge without the cover in place may cause the revolving parts of the centrifuge to vibrate, which causes excessive wear of the machine.

Do not try to stop the centrifuge with your hands. It is generally best to let the machine stop by itself. A brake may be applied if the centrifuge is equipped with one. The brake should be used with caution, as braking may cause some resuspension of the sediment. Many laboratories discourage use of the brake except where it is evident that a tube or tubes have broken in the centrifuge.

Centrifuges should be checked, cleaned, and lubricated regularly to ensure proper operation.

Centrifuges

Centrifuges are motorized devices that rotate at a high speed (Figures 23.3 and 23.4). The speed is stated as *revolutions per minute (rpm)*. Centrifuges are used to separate components of varying densities contained in liquids by spinning them at high speeds. Through centrifugal (moving away from a center) force, heavier or solid components move to the lower part of the container, and the lighter substances move to the upper part of the container. By this process the two substances, solid material and fluid supernatant, are separated.

Centrifuges are used in every department of a clinical laboratory. In a physician's office or health care agency, centrifuges will be used if a microscopic analysis of urine is performed and also when serum is required for hematology or blood chemistry laboratory tests.

There are numerous types of centrifuges available. Each must be selected according to the intended use. Centrifuges commonly used in a physician's office or clinic are table models. One type is used for routine blood and urine separations (Figure 23.3), and

Figure 23.3
Centrifuge used for blood and urine separations.

another type is used for microhematocrit applications (Figure 23.4). The speed at which these centrifuges operate varies from 3,200 rpm for the routine blood and urine separations to 11,500 to 15,000 rpm for the microhematocrit centrifuges. Special centrifuge tubes should be used in the centrifuges for serum or urine separations. These tubes are either conical or round-bottomed in shape and made of a special quality glass. Some Vacutainer tubes used for blood collection may also be put into the centrifuge. Capillary tubes are to be used in the microhematocrit centrifuges. It is important that you always use tubes that are the correct size and strength for the required application.

In the centrifuge there are special centrifuge cups with rubber cushions that are used to hold the tubes containing the blood or urine samples. Be certain that the cushions are at the bottom of the holders before you place the tubes into them.

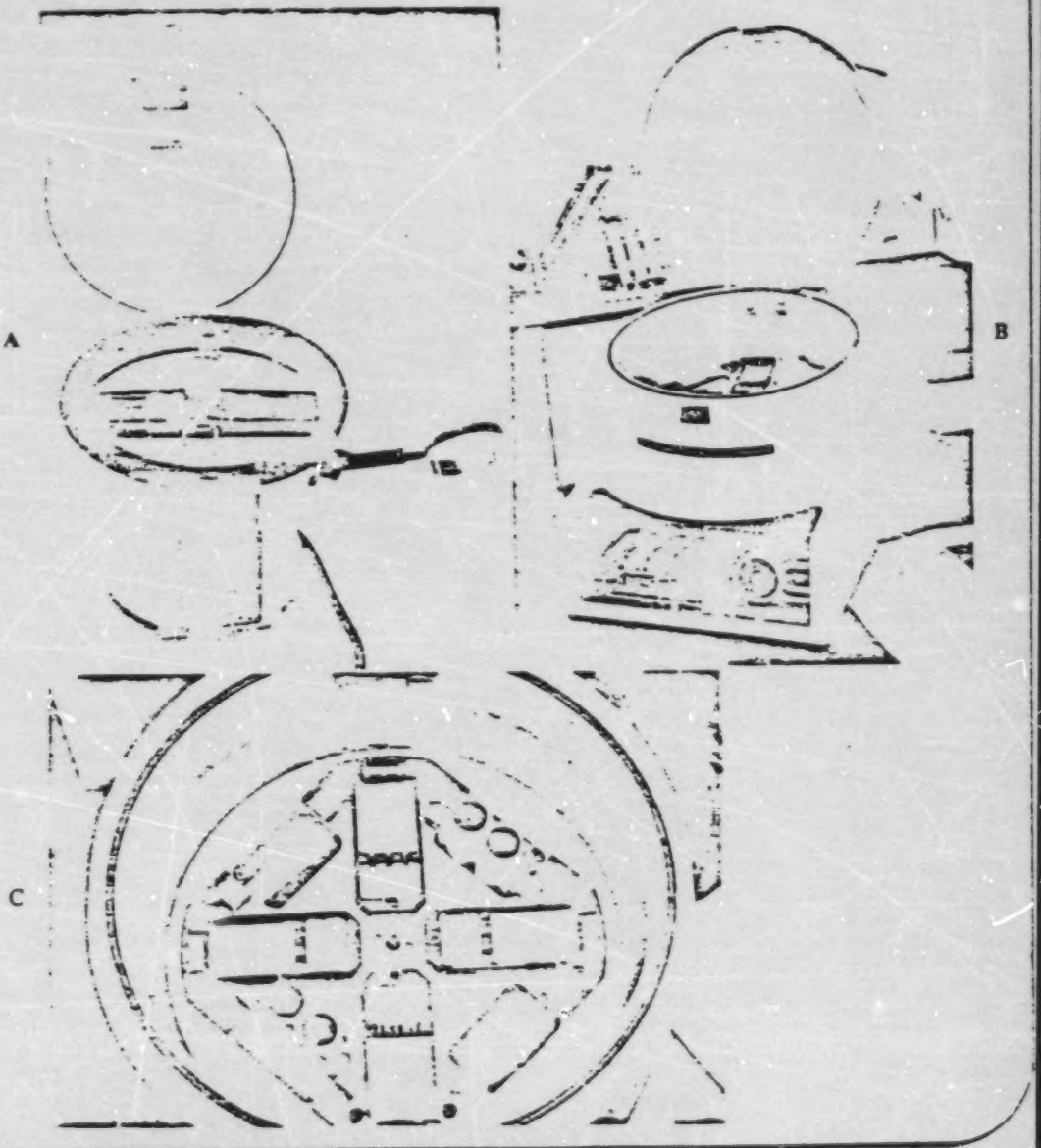


Figure 23.4
A and B. Centrifuges used for microhematocrit applications. **C.** View inside TRIAC centrifuge. Capillary tubes will be placed inside numbered columns.

PLACEMENT OF TUBES IN THE CENTRIFUGE

When you place a tube containing a specimen into the centrifuge you must counterbalance it with a tube of similar design and weight. This other tube must be placed directly opposite the tube containing the specimen and should contain a liquid of equal weight. Water can usually be used for this purpose. If you do not balance the load in a centrifuge, severe vibration of the centrifuge may occur and you may possibly lose the specimens. *Do not* use tubes that are cracked or badly scratched, because they may break under the stress of the centrifugal force. If breakage does occur, immediately turn the centrifuge off. Don rubber gloves and clean the centrifuge cushion and cup. You must clean these areas before using the centrifuge again to avoid additional breakage of tubes.

OPERATING THE CENTRIFUGE

When you operate the centrifuge you must close the cover. (Many newer models will not work if you do not close the cover.) If you are using an older model centrifuge, *do not* open the cover until the rotor has completely stopped. *Do not* brake sharply when using centrifuges that operate with hand brakes. Always use tubes that are the correct size and strength for the required application. Electrical appliances such as the centrifuge should have three-pronged grounding plugs, and there should be sufficient grounded outlets available. Frequent lubrication, calibration, and cleaning are required for the proper operation of all centrifuges. Specific instructions for operating each centrifuge are provided by the manufacturer. Read these instructions completely and carefully before you operate any centrifuge.

JOB SHEET

004-001-002

Select the BEST answer.

1. The separation of a solid material from a liquid, the recovering of solid materials form suspensions, and the separation of serum or plasma from cells in blood specimens is

   A. extraction.
   B. diffusion.
   C. centrifugation.
   D. pipetting.

2. Although the setting on the dial does not necessarily correspond directly to R/min., the _____ is used to set the desired speed.

   A. dial
   B. push-button
   C. knob
   D. rheostat

3. In the _____ centrifuge, the cups are held in a rigid position at a fixed angle making the process of centrifuging more rapid.

   A. horizontal
   B. angle head
   C. vertical
   D. conventional

4. An important rule to remember in using a centrifuge is always _____ the tubes placed in a centrifuge.

   A. even off
   B. weigh
   C. balance
   D. look at

5. For most laboratory determinations, _____, having the same specific gravity, may be used to balance a load.

   A. blood
   B. urine
   C. liquid
   D. water

6. In addition to the danger of broken glass, using the centrifuge without the _____ in place may cause revolving parts of the centrifuge to vibrate, causing excessive wear of the machine.

   A. top
   B. cover
   C. cord
   D. cap

7. Do not try to stop the centrifuge with your _____ and use the brake with caution.

   A. friend
   B. hands
   C. handle
   D. dial

8. Centrifuge should be checked, cleaned, and lubricated _____to ensure proper operation.

   A. daily
   B. weekly
   C. monthly
   D. regularly

9. Before operation of a centrifuge check the _____directions and be instructed on its proper use. (SAFETY COUNTS).

   A. procedural
   B. posted
   C. safety
   D. manufacturer's

10. Through centrifugal force, _____components move to the lower part of the container, and the _____move to the upper part of the container.

    A. lighter, heavier
    B. heavier, lighter
    C. fluid, solid
    D. solid, fluid

11. _____tubes are to be used in the microhematocrit centrifuges.

    A. Capillary
    B. Vacutainer
    C. Correct-sized
    D. Cushioned

12. Special centrifuge cups with rubber_____are used to hold the tubes containing the blood or urine samples and are at the bottom of the holders before you place the tubes in them.

    A. suctions
    B. cushions
    C. stoppers
    D. tubes

13. If breakage of tubes does occur, _____ turn off the centrifuge and don rubber gloves to clean the centrifuge cushion and cup.

    A. eventually
    B. immediately
    C. gradually
    D. hurriedly

14. If braking is necessary, brake

    A. gently.
    B. immediately.
    C. sharply.
    D. timely.

15. Electrical appliances such as a centrifuge should have three-pronged _____ plugs, and there should be sufficient _____ outlets available.

    A. electrical
    B. grounded
    C. indoor
    D. wall

INTERMEDIATE OBJECTIVE #2

Operate centrifuge.

LEARNING STEPS (Activities)	RESOURCES
1. Observe Resource #1 for a demonstration of the operation of a centrifuge.	1. See instructor.
2. Refer to Resource #2 for manufacturer's directions.	2. See procedure manual in M.A. lab.
3. Complete Resource #3 for practice on operating a centrifuge.	3. Job Sheet 004-002-003, "Practice Operating a Centrifuge", page 12 in this SLG.
4. When you have mastered this task, see Resource #4 for a performance evaluation.	4. See instructor.
5. Complete Resource #5 for a written evaluation.	5. Written Criterion Examination, Task #004, "Operate Centrifuge", in LRC. See instructor for evaluation.
6. Proceed to Resource #6 for the next Learning Guide.	6. See instructor or task list.

JOB SHEET

004-002-003

"Practice Operating a Centrifuge"

Directions to the student:

Given a centrifuge by the instructor and referring to the manufacturer's directions ahead of time, practice operating the centrifuge.

Necessary tool and equipment:

Centrifuge
Test tubes or capillary tubes
Blood or urine samples

Procedure:

1. Place tubes in proper position to balance. Tubes must have equal amounts of specimen.
2. Place cover on tightly.
3. Turn to proper R/min.
4. Set time.
5. Allow centrifuge to stop completely.
6. Remove centrifuged samples.

PERFORMANCE/PRODUCT CHECKLIST

Program: MEDICAL ASSISTING

Task No: 004

Student's Name: _____ Date Of Attempt: _____

Evaluator's Name: _____ Evaluation Site: _____

Performance Attempt: 1 2 3 4

Terminal Performance Objective:

Given a centrifuge and necessary tools, you will operate a centrifuge.

Directions To The Student:

Before attempting this task for mastery, carefully review this checklist. You will be evaluated on the basis of this checklist. When you feel you are ready for evaluation, contact your instructor. You must complete your performance within 10 minutes and must score at least 5 out of 6 points or 90 % for mastery. Critical items are marked with an asterisk (*). These items must be satisfactorily completed.

Directions To The Evaluator:

The student will contact you when ready for the evaluation. The student must complete the performance within 10 minutes and must score 5 out of 6 points or 90 % and all items marked with an asterisk (*) must be satisfactorily completed.

CRITICAL ITEMS	ITEMS TO BE OBSERVED OR CHECKED	RATING	
		YES	NO
*	1. Balance tubes in centrifuge.		
*	2. Place cover of centrifuge tightly.		
*	3. Turn to proper R/min.		
*	4. Set timer.		
*	5. Allow centrifuge to stop completely.		
	6. Remove cnetrifuged samples.		

TOTAL POINTS EARNED =

POINTS NEEDED FOR MASTERY = 5
TOTAL POINTS POSSIBLE = 6

PROGRAM MEDICAL ASSISTING

CRITERION EXAM

TASK = 004

DIRECTIONS:

THE PURPOSE OF THIS EXAM IS TO DETERMINE WHETHER OR NOT YOU HAVE UNDERSTOOD THE INFORMATION ON operating centrifuge.

Each of the questions or incomplete statements below is followed by several words, phrases, or a series of numbers. Choose the one which best answers the question or completes the statement correctly. Place the letter associated with that choice (A,B,C or D) in the numbered blank space on your ANSWER SHEET. DO NOT WRITE ON THIS TEST!!! To master this exam you must answer 14 out of 15 items correctly, 90%.

EVALUATION SHEET

Written Criterion Examination

TASK #004

"Review Centrifuge"

Select the BEST answer.

1. Centrifuge should be checked, cleaned, and lubricated _____ to ensure proper operation.

   A. daily
   B. weekly
   C. monthly
   D. regularly

2. In the _____centrifuge, the cups are held in a rigid position at a fixed angle making the process of centrifuging more rapid.

   A. horizontal
   B. angle head
   C. vertical
   D. conventional

3. In addition to the danger of broken glass, using the centrifuge without the _____in place may cause revolving parts of the centrifuge to vibrate, causing excessive wear of the machine.

   A. top
   B. cover
   C. cord
   D. cap

4. _____tubes are to be used in the microhematocrit centrifuges.

   A. Capillary
   B. Vacutainer
   C. Correct-sized
   D. Cushioned

5. The separation of a solid material from a liquid, the recovering of solid materials from suspensions, and the separation of serum or plasma from cells in blood specimens is

   A. extraction.
   B. diffusion.
   C. centrifugation.
   D. pipetting.

6. Before operation of a centrifuge check the _____ directions and be instructed on its proper use. (SAFETY COUNTS).

   A. procedural
   B. posted
   C. safety
   D. manufacturer's

7. Although the setting on the dial does not necessarily correspond directly to R/min., the _____ is used to set the desired speed.

   A. dial
   B. push-button
   C. knob
   D. rheostat

8. Electrical appliances such as a centrifuge should have three-pronged _____ plugs, and there should be sufficient _____ outlets available.

   A. electrical
   B. grounded
   C. indoor
   D. wall

9. Special centrifuge cups with rubber _____ are used to hold the tubes containing the blood or urine samples and are at the bottom of the holders before you place the tubes in them.

   A. suctions
   B. cushions
   C. stoppers
   D. tubes

10. An important rule to remember in using a centrifuge is always _____ the tubes placed in a centrifuge.

    A. even off
    B. weigh
    C. balance
    D. look at

11. If braking is necessary, brake

    A. gently.
    B. immediately.
    C. sharply.
    D. timely.

12. Do not try to stop the centrifuge with your _____ and use the brake with caution.

A. friend
B. hands
C. handle
D. dial

13. For most laboratory determinations, _____, having the same specific gravity, may be used to balance a load.

A. blood
B. urine
C. liquid
D. water

14. Through centrifugal force, _____ components move to the lower part of the container, and the _____ move to the upper part of the container.

A. lighter, heavier
B. heavier, lighter
C. fluid, solid
D. solid, fluid

15. If breakage of tubes does occur, _____ turn off the centrifuge and don rubber gloves to clean the centrifuge cushion and cup.

A. eventually
B. immediately
C. gradually
D. hurriedly

LCJC

LAKE COUNTY AREA VOCATIONAL CENTER

COMPETENCY-BASED INDIVIDUALIZED VOCATIONAL EDUCATION INSTRUCTION

STUDENT LEARNING GUIDE

Produced By Rosemarie Meyer, RN, CMA Date 8/84

TASK: Measure and Calculate Dosage

PURPOSE: As a Medical Assistant you will need to know about the three systems of measurements used in measuring doses of medication. You will need to know how to solve simple dosage problems and how to convert dosages from one system measurements to another. This learning guide will assist you to measure and calculate dosage.

Medical Assisting

Program	Task	Est. Time	Prereq.
07.0904	100	5 hrs	

jlk

LEARNING CONTRACT (optional)

1. STUDENT DATA

NAME _____ SOCIAL SECURITY NUMBER _____

LENGTH OF CONTRACT (NORMAL TIME IN HOURS) _____

2. TERMINAL PERFORMANCE OBJECTIVE

Given: the necessary tools and equipment

You will: Measure and calculate dosage

How well: To master this task you must score 4 out of 5 (90%) on a performance evaluation and 9 out of 10 (90%) on a written exam.

2a. INTERMEDIATE OBJECTIVE(s)

1. Describe measurement and dosage calculation.
2. Measure and calculate dosage.

3. AGREEMENT

I, _____ agree to complete the above stated terminal performance requirement within _____ to _____. I further recognize that the conditions of the contract (performance and time agreement) report my ability to perform the requirements of the occupation and record my progress.

Student's Signature _____

Instructor's Signature (verifies competency) _____

INTERMEDIATE OBJECTIVE #1

1. Describe measurement and dosage calculation.

LEARNING STEPS (Activities)

1. Read Resource #1 for information on measurement and dosage calculation.

2. Complete resource #2 for a review on this objective.

3. Proceed to resource #3.

RESOURCES

1. Information sheet 100-001-001, "Measurement and dosage calculation" pages 3-17 , in this Student learning guide.
   (Information taken from textbook, Administering Medications by T. Bayt, Bobbs Merrill Educ. Publish. Indianapolis)

2. Activity sheet 100-001-002, "Review Measurement and Dosage Calculation, pages 18 - 19, in this guide. See instructor for evaluation.

3. MPO #2, page 20 , in this guide.

INFORMATION SHEET

#100-001-001

"MEASUREMENT AND DOSAGE CALCULATION"

Taken from textbook: Administering Medications by T. Bayt, Bobbs-Merrill Educ. Publish, Indianapolis

Vocabulary

apothecary: old word for pharmacist
Arabic numerals: 1, 2, 3, 4, and so on
calculation: figuring out a mathematical problem
centimeter: one-hundredth of a meter
conversion: changing from one unit of measurement to another
dosage range: set of quantities of a drug that are strong enough to produce therapeutic effects, but not so strong as to be toxic to the body
dram: 60 grains (1 fluidrum = 60 minims)
equivalents: things that are equal in amount or value
formula: a mathematical rule for doing a certain kind of math problem
fraction: a mathematical way of talking about an amount that is part of a whole or a ratio between two numbers
grain: basic unit of weight in the apothecaries' system
gram: basic unit of weight in the metric system
kilogram: one thousand grams
liter: basic unit of volume in the metric system
metric: system of measurement based on the meter in which all units are multiples of ten
microgram: one-millionth of a gram
milligram: one-thousandth of a gram
milliliter: one-thousandth of a liter (same as cubic centimeter)
minim: basic unit of volume in the apothecaries system
Roman numerals: I, II, III, IV, V, and so forth
unit: (1) basic quantity in a measurement system; (2) a way of telling the strength of hard-to-measure drugs such as antibiotics (e.g., 100,000 units of penicillin)
volume: amount of space taken up by a substance

Systems of measurement

Measurement has always been an important part of prescribing and administering medications. This is so because different amounts of a drug give different effects. Some drugs are deadly poisons, but when given in tiny amounts can help relieve disorders. Other drugs are useless for therapy unless given in large amounts.

Most drugs have a certain dosage range, that is, a range of quantities that can produce therapeutic effects (Figure 4-1). Doctors prescribe an amount within the dosage range depending on how strong an effect is needed and on the patient's age and physical condition. Doses less than the dosage range do not produce any therapeutic effects. Doses more than the dosage range are harmful to the body and can be fatal.

To get the drug effects they want, physicians and pharmacists through the ages have tried to make dosages very exact by measuring drugs carefully. However, they have not all used the same units of measurement. There are different measurement systems, each having their own units of weight and volume.

INFORMATION SHEET

#100-001-001

"MEASUREMENT AND DOSAGE CALCULATION"

(continued)

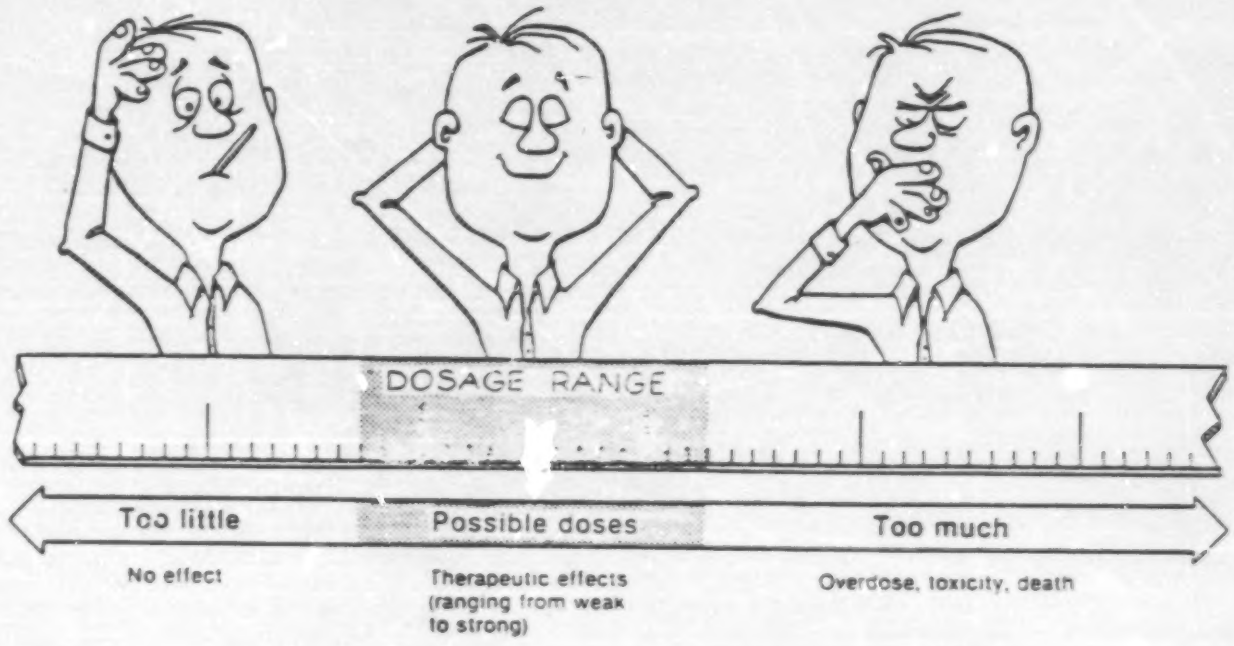


Fig. 4-1 The physician chooses a certain dose within the dosage range according to the needs of the individual patient.

Today, three different systems of measurement are commonly used in the medical field. You should be familiar with the units of weight and volume found in each system. Dosages on a medication order may be expressed in anything from milliliters or cubic centimeters to drops, teaspoons, drams, or minims. You need to know what each of these quantities means so that you can measure out the doses properly. In addition, you may be asked to convert (change) from one unit or system to another in the course of your daily routine. You need to know how to use conversion tables to convert from milligrams to grams, from milliliters to teaspoons, from grains to milligrams, and so forth.

The three systems of measurement used in ordering medications are the apothecaries' system, the metric system, and the household system.

APOTHECARIES' SYSTEM

The apothecaries' system of measurement is very old. It was brought to the United States from England during the eighteenth century. Colonial pharmacists (apothecaries) used it when compounding and measuring their medicinal preparations. The system is gradually being phased out in favor of the easier-to-use metric system, but many older physicians and patients prefer the apothecaries' system because it is more familiar to them.

The basic unit of weight in the apothecaries' system is the grain (gr). It was originally supposed to be the weight of one grain of wheat. The basic unit of volume is the minim (m). The term "volume" means the amount of space that something takes up. A minim is the space taken up by a quantity of water that weighs the same as a grain of wheat.

Table 4-1 lists all the units of weight and volume in the apothecaries' system. Note especially the abbreviations for these units. You need to be able to recognize them on a medication order and write them on a medication chart.

In the apothecaries' system, dosage quantities are written out in lowercase Roman numerals (see Table 4-2). The roman numerals are written *after* the unit of measurement, e.g., ℈ ii meaning 2 drams.

If the quantity of units is higher than 15, Arabic numerals can be used (15, 16, 17, etc.). Arabic numerals are usually written before the unit of measurement.

Table 4-1 The apothecaries' system

WEIGHT (DRY)	VOLUME (LIQUID)
grain (gr)	minim (m, m_{γ})
dram (dr or ʒ)	fluidram (fl dr, ʒ, or f ʒ)
ounce (oz or ℥)	fluidounce (fl oz, ℥, or f ℥)
pound	pint (pt)
ton	quart (qt)

EQUIVALENTS

A minim of liquid weighs 1 grain

60 grains or 60 minims = 1 dram or fluidram

8 drams or fluidrams = 1 ounce or fluidounce

Table 4-2 Lower-case Roman numerals

1 i	6 vi	11 xi
2 ii	7 vii	12 xii
3 iii	8 viii	13 xiii
4 iv	9 ix	14 xiv
5 v	10 x	15 xv

$\overline{ss}$ = ½

for example, 25 gr, although many people prefer to write them after the unit, to avoid confusing grains with grams in the metric system. Quantities less than one (½, ¾) and mixed fractions (2¾, 4½) are also usually written with Arabic numerals before the unit. The only exception is the quantity one-half, for which the symbol ss is used with roman numerals after the unit.

Here are some examples:

f℥ vii = 7 fluid ounces

℈ iv = 4 drams

gr iss = 1½ grains

5¼ dr = 5¼ drams

$\frac{1}{150}$ gr (also gr $\frac{1}{150}$) = $\frac{1}{150}$ grain

15 gr (also gr 15) = 15 grains

30 m = 30 minims

METRIC SYSTEM

The metric system is used throughout the world and is gradually becoming accepted in the United States, especially in the field of medicine. It is a simple, logical system of measurement based on units of ten.

A unit of length, the meter, is the foundation of the metric system. It is actually one 10-millionth of the distance between the North Pole and the Equator. Metric volume is measured in fractions of a liter (L). Weight is measured in grams (g).

Prefixes added to the words "meter," "gram," and "liter" indicate smaller or larger units in the system (see Table 4-3). All units are a result of either multiplying or dividing by 10, 100, or 1000. The centimeter, for example, is $\frac{1}{100}$ of a meter. A millimeter is $\frac{1}{1000}$ of a meter. A kilometer is 1000 meters.

In the metric system, units of length, weight, and volume are related to each other in systematic ways. The unit of volume most often used in preparing medications is the milliliter (ml), which is one-thousandth of a liter. One milliliter is the liquid contents of a cube measuring 1 centimeter (cm) on a side, or 1 cubic centimeter (cc). One liter is the liquid contents of a cube measuring 10 cm on a side, or 1000 cc. One gram is equal to the weight of 1 ml (or cc) of water. One liter contains 1000 ml of water, and so it weighs 1000 g (1 kilogram). These relationships are shown in Figure 4-2.

Metric doses are always written out in Arabic numerals. Fractions of metric doses are written as decimal fractions. For example, one-half gram is 0.5 g. In reading medication orders, pay special attention to where the decimal point is

Table 4-3 Prefixes in the metric system

GREEK (MULTIPLY)	LATIN (DIVIDE)
deca — × 10	deci — ÷ 10
hecto — × 100	centi — ÷ 100
kilo — × 1000	milli — ÷ 1000
	micro — ÷ 1,000,000

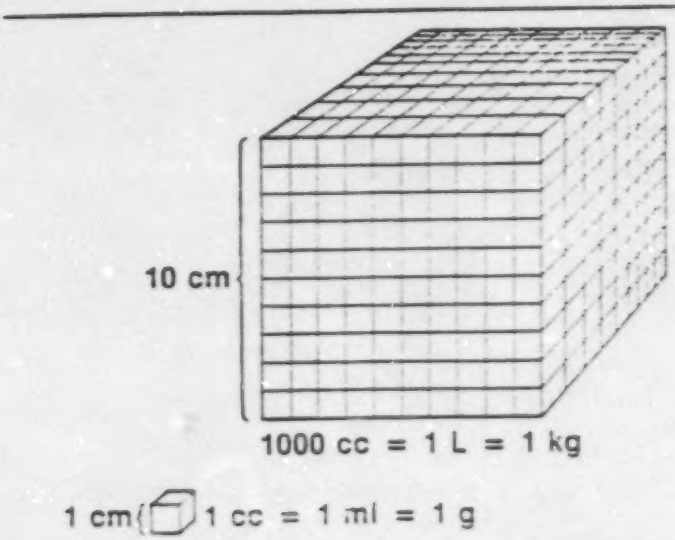


Fig. 4-2 Relationships among units of length, volume, and weight in the metric system.

placed. The differences between 0.05 g, 0.5 g, and 5.0 g are huge when it comes to doses of medicine. A mistake could be dangerous.

Table 4-4 lists the basic units of volume and weight in the metric system and their equivalents. The bottom of the table shows how to change from milligrams to grams and vice versa. Note especially the instructions, because these are simple conversions you will probably make often on the job. The conversions are easy if you remember the hints shown in Table 4-4.

HOUSEHOLD SYSTEM

The household system of measurement is actually more complicated than the metric and apothecaries' systems. However, most of us have grown up using its basic units—feet, inches, miles, pints, quarts, pounds, and so on—so the household system is quite familiar to us.

For medical purposes, household measures are not as accurate as apothecaries' or metric measures. So why use them at all? The reason is that medicine orders sometimes have to be translated into terms that patients can understand and use on their own. Particularly in home care, patients need to be able to take medicines in doses that can be measured with utensils they have on hand (teaspoons, tablespoons, medicine droppers, etc.).

The basic units of the household system are listed in Table 4-5. All household

Table 4-4 The metric system

WEIGHT	VOLUME
microgram (µg, mcg)	milliliter (ml)
milligram (mg, Mgm)	cubic centimeter (cc, cm^3)
gram (g, Gm)	kilogram (kg)
liter (L, ℓ)	

EQUIVALENTS

One milliliter is the same as 1 cubic centimeter, and both weigh 1 gram

1000 milliliters = 1 liter = 1000 cubic centimeters

1000 micrograms = 1 milligram

1000 milligrams = 1 gram

1000 grams = 1 kilogram

100 milligrams = 0.1 gram

10 milligrams = 0.01 gram, etc.

SIMPLE CONVERSIONS

From grams to milligrams:

g × 1000 = mg

Hint: Move decimal point three places to the *right*

0.25 g = 250 mg

From milligrams to grams:

mg ÷ 1000 g

Hint: Move decimal point three places to the *left*

500 mg = 500 g = 0.5 g

dosages are written out in Arabic numerals.

DRUGS THAT ARE HARD TO MEASURE

Certain antibiotics and hormones from animal sources are impossible to weigh and measure in ordinary ways. Their strength is judged by the quantity shown to cause certain effects in laboratory animals and human volunteers—the bioassay technique you studied in Unit 1. Rather than being dispensed in grams or grains, these drugs are dispensed in solutions labeled with a certain number of **units** (U) per cubic centimeter or milliliter. Examples of these drugs are penicillin and insulin.

Table 4-5 The household system

WEIGHT (DRY)	VOLUME (LIQUID)	EQUIVALENTS
ounce (oz)	drop (gt); drops (gtt)	16 ounces = 1 pound
pound (lb)	teaspoon (t, tsp)	3 teaspoons = 1 tablespoon = ½ ounce
ton	tablespoon (T, tbsp)	16 tablespoons = 1 cup = 8 fluid ounces
	teacup (6 oz)	2 cups = 1 pint
	cup (c) or glass (8 oz)	2 pints = 1 quart
	pint (pt)	4 quarts = 1 gallon
	quart (qt)	
	gallon (gal)	

Converting between measurement systems

From time to time you will find it necessary to change, or convert, from one system of measurement to another. A physician will order medicine in grains, but the hospital pharmacy may send up the medication in grams. Or perhaps an order written for milliliters will have to be converted into teaspoons for a patient who will be taking the medicine at home. These types of conversions are usually performed by the pharmacist or the nurse in charge. But other health workers should also know how to make simple conversions by referring to a conversion table. Table 4-6 shows the equivalents between measures in the apothecaries', metric, and household systems. As you can see, the equivalents are not exact, but approximate. A 10% error usually occurs in making conversions.

You can make most of the conversions you need if you know these four basic equivalents:

0.1 mg = $\frac{1}{600}$ gr

1 mg = $\frac{1}{60}$ gr

60 mg = 1 gr

1 g = 15 gr

Table 4-6 Commonly used measurement system equivalents[a]

APOTHECARIES'	METRIC	HOUSEHOLD
Liquid volume		
1 minim (♏) or m)	0.06 ml (or cc)	1 drop
15 minims	1 ml	15 drops (gtt)[b]
1 fluidram (f℥)	4–5 ml	1 teaspoon (60 gtt)
4 fluidrams	15 ml	1 tablespoon
1 fluidounce (f℥)	30 ml	2 tablespoons (1 oz)
	180 ml	1 teacup (6 oz)
	240 ml	1 cup or glass (8 oz)
	500 ml	1 pint (16 oz)
	750 ml	1.5 pints (24 oz)
	1000 ml (1 L)	1 quart (32 oz)
Dry weight		
$\frac{1}{60}$ gr	1 mg	
1 gr	60 mg	
7½ gr	500 mg (0.5 g)	
15 gr	1000 mg (1 g)	
60 gr (1 dram)	4 g	
1 oz	30 g	1 oz
	500 g	1.1 lb
	1000 g (1 kg)	2.2 lb

[a] *Equivalents are approximate.*
[b] *This figure varies. The number of drops per milliliter depends on the substance being measured.*

If you can remember these, it is easy to work out other equivalents. Table 4-7 shows how this can be done. Study the table carefully, and note the simple formulas for converting between systems. You may use this table to make conversions needed in the dosage calculation exercises at the end of this unit. However, if you memorize the four basic equivalents shown above, you may be able to make the conversions in your head. For example, if you know that 1 gr is equivalent to about 60 mg, then logically 5 gr is about 300 mg and ¼ gr is about 15 mg.

A close look at Figure 4-3 should also be helpful. It shows the relative sizes of containers you might use to measure out doses in the various systems.

Table 4-7 Simple conversions between the metric and apothecaries' systems

MILLIGRAMS —— GRAINS	GRAMS —— GRAINS
0.1 mg = $\frac{1}{600}$ gr	1 g = 15 gr
0.2 mg = $\frac{1}{300}$ gr = $\frac{1}{300}$ gr	0.1 g = $\frac{15}{10}$ gr = $1\frac{1}{2}$ gr
0.3 mg = $\frac{1}{200}$ gr = $\frac{1}{200}$ gr	0.25 g = $\frac{15}{4}$ gr = $3\frac{3}{4}$ gr
0.4 mg = $\frac{1}{150}$ gr = $\frac{1}{150}$ gr	0.5 g = $\frac{15}{2}$ gr = $7\frac{1}{2}$ gr
0.5 mg = $\frac{1}{120}$ gr = $\frac{1}{120}$ gr	
0.6 mg = $\frac{1}{100}$ gr = $\frac{1}{100}$ gr	0.75 g = $\frac{3 \times 15}{4}$ gr = $11\frac{1}{4}$ gr
	2 g = 30 gr
1 mg = $\frac{1}{60}$ gr	5 g = 75 gr
2 mg = $\frac{1}{30}$ gr = $\frac{1}{30}$ gr	*Hint:*
3 mg = $\frac{1}{20}$ gr = $\frac{1}{20}$ gr	gr × 60 = mg
5 mg = $\frac{1}{12}$ gr = $\frac{1}{12}$ gr	mg ÷ 60 = gr
10 mg = $\frac{1}{6}$ gr = $\frac{1}{6}$ gr	g × 15 = gr
15 mg = $\frac{1}{4}$ gr = $\frac{1}{4}$ gr	gr ÷ 15 = g
20 mg = $\frac{1}{3}$ gr = $\frac{1}{3}$ gr	
30 mg = $\frac{1}{2}$ gr = $\frac{1}{2}$ gr	
60 mg = 1 gr	
120 mg = 2 gr	
180 mg = 3 gr	
240 mg = 4 gr	
300 mg = 5 gr	
600 mg = 10 gr	

Dosage calculation

The job of calculating dosages is much easier today than in the past. Now in some health facilities pharmacists do all of the calculating. They prepare drugs in unit packages that contain the correct amount of a drug for a single dose. In your facility, however, you may have to make simple dosage calculations as part of your daily routine. You will need to know how to do this correctly and confidently. In medication administration there is no room for error!

In this section, you will learn two simple procedures that can be used to calculate almost any type of dosage problem. The only math you need to know is how to multiply and divide using whole numbers and fractions. Use paper and pencil to do your calculations, and check them over carefully for errors. Some of the calculations are easy to do in your head. But practice with paper and pencil until you have mastered the techniques presented.

A brief review of fractions is provided in this unit beginning on page 77. To refresh your memory, turn to that review now, before reading the next section. If your arithmetic skills are weak, you will need some extra practice. There are many books available in the library or bookstore to help you brush up on your basic skills. Some of these are listed among the references at the back of this book.

CALCULATING NUMBER OF TABLETS OR CAPSULES

A type of calculation you will probably run into often is the following:

PROBLEM 1 The doctor orders 200 mg of a drug to be given 3 times a day. The pharmacy sends up a bottle of 50-mg capsules. You have to decide how many capsules to give for each dose.

A simple formula can be used to help you figure this out. The formula is:

Desired dose (what you WANT)	÷	Available dose per tablet or capsule (what you HAVE)
	=	Number of tablets or capsules

or

$$\frac{\text{WANT}}{\text{HAVE}} = \text{Number of tablets or capsules}$$

What this formula does is help you set up a fraction that you can simplify using the rules for fractions (see Math Review). Applying the formula to Problem 1, you get:

Dose ordered (WANT): 200 mg
Available packaging (HAVE): 50-mg caps

$$\frac{\text{WANT}}{\text{HAVE}} = \frac{200\text{ mg}}{50\text{ mg}} = \frac{\overset{4}{\cancel{200}\text{ mg}}}{\underset{1}{\cancel{50}\text{ mg}}} = 4 \text{ capsules}$$

The correct dose, then, would be four capsules 3 times a day.

PROBLEM 2 The doctor orders 350 mg to be given once a day. All you have on

hand are 100-mg tablets. How many tablets should you give?

$$\frac{\text{WANT}}{\text{HAVE}} = \frac{350\text{ mg}}{100\text{ mg}} = \frac{\overset{3.5}{\cancel{350\text{ mg}}}}{\underset{1}{\cancel{100\text{ mg}}}} = 3\tfrac{1}{2}\text{ tablets}$$

Note that your answer included a fraction of a tablet. You may administer a half or a quarter of a tablet if the tablet is *scored* so that it breaks easily. If it is anything other than a scored tablet, ask the nurse in charge what to do. Dividing an unscored tablet is risky, and of course you should not attempt to divide capsules or specially coated tablets.

PROBLEM 3 Now try a problem involving another unit of measurement. You are to give 20 gr of aspirin to an arthritis patient. The aspirin tablets you have are 5 gr each. How many tablets do you give?

$$\frac{\text{WANT}}{\text{HAVE}} = \frac{\overset{4}{\cancel{20\text{ gr}}}}{\underset{1}{\cancel{5\text{ gr}}}} = 4\text{ tablets}$$

Note that both WANT and HAVE must be in the same unit of measurement (e.g., both milligrams or grains, etc.). This formula does *not* apply to a problem like:

$$\frac{100\text{ mg}}{5\text{ gr}}$$

PROBLEM 4 What if the dosage ordered is a fractional dosage? For example, let's say the doctor orders ½ gr and your tablets are ¼ gr. Setting up the WANT/HAVE formula, you get:

$$\frac{\frac{1}{2}\text{ gr}}{\frac{1}{4}\text{ gr}}$$ — (Remember, this line means "divided by")

To work this out, use what you know about dividing fractions. You invert the bottom fraction and turn it into a multiplication problem.

$$\frac{1}{2} \div \frac{1}{4} = \frac{1}{\cancel{2}_{1}} \times \frac{\overset{2}{\cancel{4}}}{1} = 2\text{ tablets}$$

INFORMATION SHEET

#100-001-001

"MEASUREMENT AND DOSAGE CALCULATION"

(continued)

PROBLEM 5 The same procedure can be applied to situations where drugs are mixed into solutions. For example, the label on a bottle of elixir says it contains 5 gr of medication per teaspoon. The doctor has ordered 15 gr of medication.

$$\frac{\text{WANT}}{\text{HAVE}} = \frac{15 \text{ gr}}{5 \text{ gr/tsp}} = 3 \text{ tsp}$$

PROBLEM 6 It also works for units of penicillin mixed in sterile water for injection. A vial states that it contains 100.000 units of penicillin per cubic centimeter. You are to inject 300.000 units.

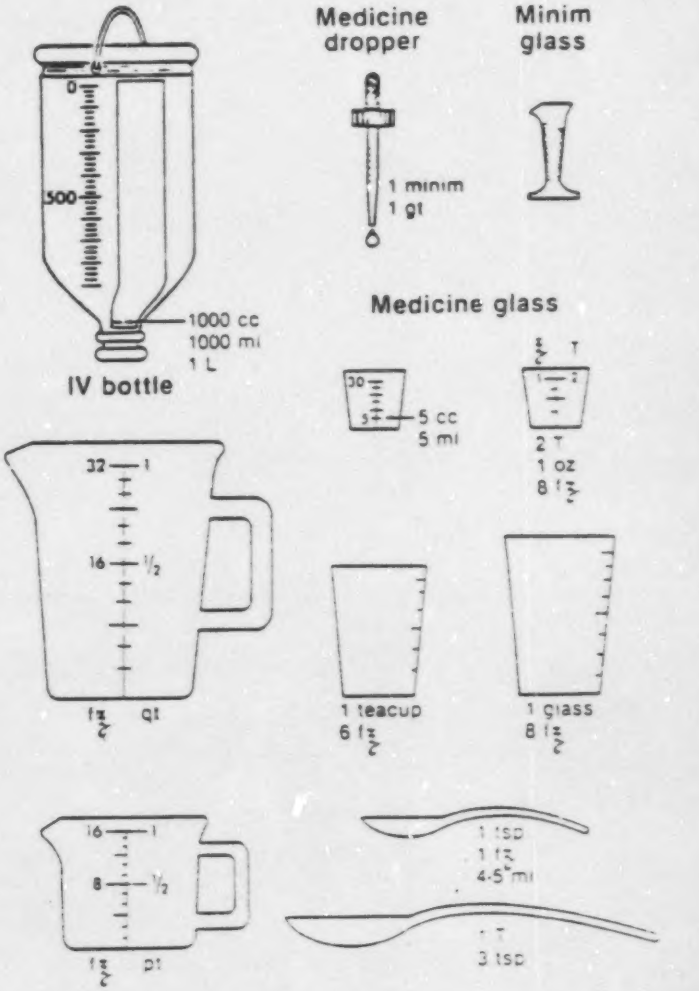


Fig. 4-3 Relative sizes of measuring containers.

$$\frac{\text{WANT}}{\text{HAVE}} = \frac{300.000 \text{ units}}{100.000 \text{ units/cc}} = 3 \text{ cc}$$

DOSAGE CALCULATIONS WITH CONVERSIONS

Suppose that the doctor orders a dose in grams, but your capsules are labeled in milligrams. Perhaps the order is in grains and your tablets are labeled in milligrams. Or suppose that the order is in milliliters and you want to instruct the patient in how much to take at home using a teaspoon.

Dosage calculations in which you need to convert from one system or unit of measurement to another cannot be handled by the simple WANT/HAVE formula. A more complex formula is needed, but it is easy to use and can be adapted to a variety of situations. The formula is:

Dosage in ordered unit (KNOWN) × Conversion fraction (relation of UNKNOWN to KNOWN units) = Dose in desired unit (UNKNOWN)

or

KNOWN × conversion fraction = UNKNOWN

This formula is best explained in the context of some sample problems.

PROBLEM 7 The doctor orders 0.5 g of ampicillin to be given 4 times a day. You want to know how many milligrams one dose would be. Your problem is:

0.5 g = ? mg (KNOWN unit is 0.5 g; UNKNOWN unit is ? mg)

To solve the problem, set up a calculation that will allow you to cancel the gram unit and give you the answer in milligrams.

$$0.5 \text{ g} \times \frac{? \text{ mg}}{? \text{ g}} = \text{answer in milligrams}$$

You do this by means of a "conversion fraction." This fraction differs according to the particular problem. It is designed to show the equivalence between the known and unknown units of measurement. The known type of unit should be in the denominator. For this problem, the conversion fraction is $\frac{? \text{ mg}}{? \text{ g}}$. You must fill in the missing quantities.

First you set the quantity of either unit to 1. Then you find out how many of the other unit are contained in that quantity. In this case, let us set the quantity of grams at 1. One gram contains 1000 mg, so you fill in the fraction like this:

$$\frac{1000 \text{ mg}}{1 \text{ g}}$$

Note that this fraction is equal to 1, because the numerator and the denominator both represent the same quantity, only in different units. *Remember, the denominator must be in the same unit of measurement as the KNOWN dose.*

Now you can solve the problem by canceling the gram unit and multiplying:

$$0.5 \text{ g} \times \frac{1000 \text{ mg}}{1 \text{ g}} = 0.5 \times 1000 \text{ mg}$$
$$= 500 \text{ mg}$$

PROBLEM 8 Take another example, this one involving a conversion between household measures. You are to give a patient 6 tsp of milk of magnesia as necessary for constipation. How many tablespoons would that be? In other words, 6 tsp = ? T (KNOWN unit is 6 tsp, UNKNOWN is ?T).

Set up the calculation so that you can cancel out the teaspoons and get the answer in tablespoons:

$$6 \text{ tsp} \times \frac{? \text{ T}}{? \text{ tsp}} = \text{answer in tablespoons}$$

You know that 3 tsp = 1 T, so you can fill in the conversion fraction as $\frac{1 \text{ T}}{3 \text{ tsp}}$

Proceed to solve as follows:

$$\frac{2}{\cancel{6}\ \cancel{\text{tsp}}} \times \frac{1 \text{ T}}{\cancel{3}\ \cancel{\text{tsp}}_{1}} = 2 \text{ T}$$

PROBLEM 9 Next, try a problem that involves converting from one measurement system to another. The order is for Pro-Banthine gr ss, and you have tablets that are labeled in milligrams. Use the above procedure to find: ½ gr = ? mg.

$$\frac{1}{2} \text{ gr} \times \frac{? \text{ mg}}{? \text{ gr}} = \text{answer in mg}$$

From memory (or looking at Table 4-7), you know that 1 gr = 60 mg, so:

$$\frac{1}{\cancel{2}} \cancel{\text{gr}} \times \frac{\overset{30}{\cancel{60}} \text{ mg}}{1 \cancel{\text{gr}}} = 30 \text{ mg}$$

Now, suppose that your tablets of Pro-Banthine are 15 mg each. How many 15-mg tablets would it take to make 30 mg? Some quick mental figuring tells you that you should give the patient two tablets. If in doubt, you can use the WANT/HAVE formula, now that you have already converted from grains to milligrams.

$$\frac{\text{WANT}}{\text{HAVE}} = \frac{\overset{2}{\cancel{30}\ \cancel{\text{mg}}}}{\cancel{15}\ \cancel{\text{mg}}_{1}} = 2 \text{ tablets}$$

CHILDREN'S DOSES

As you learned in Unit 2, children need smaller doses of medicine than adults. There are two ways to adjust dosages for children: by age and by weight. In both cases, you can use the basic KNOWN/UNKNOWN procedure you have just learned. But first, here is the way children and adults are defined for the purpose of calculating dosages.

	Age	*Weight*
Infant	0–24 months (up to 2 years)	Less than 150 lb
Child	24–150 months (2 to 12½ years)	Less than 150 lb
Adult	150 months and over (more than 12½ yrs)	Over 150 lb

ADJUSTING DOSES BY AGE A 6-month-old infant is to be given a dose of tetracycline. The usual adult dose is 250 mg. You should set up the problem like this:

$$\text{Patient's age (in months)} \times \frac{\text{Usual adult dose}}{\text{Adult age (in months)}} = \text{Child's dose}$$

The adult age is always 150 months (12½ years) in this way of calculating. After filling in the proper numbers for your problem, you would get (mo = months):

$$6 \text{ mo} \times \frac{250 \text{ mg}}{150 \text{ mo}} = \frac{1500 \text{ mg}}{150} = 10 \text{ mg}$$

The infant would therefore be given 10 mg of tetracycline.

Suppose that you were giving tetracycline to an 8-year-old. Eight years is the same as 96 months ($8 \times 12 = 96$), so your problem would look like this:

$$96 \text{ mo} \times \frac{250 \text{ mg}}{150 \text{ mo}} = \frac{24000 \text{ mg}}{150} = 160 \text{ mg}$$

ADJUSTING DOSES BY WEIGHT You can figure out a child's dose by weight just as you did by age. An adult is considered to weigh 150 lb in this formula:

$$\text{Patient's weight} \times \frac{\text{Usual adult dose}}{\text{Adult weight (always 150 lb)}} = \text{Child's dose}$$

A doctor orders Dilantin for a 30-lb. child. The usual adult dose is 100 mg. Your calculation would look like this:

$$\frac{1}{\cancel{30}\ \text{lb}} \times \frac{100 \text{ mg}}{\frac{150 \text{ lb}}{5}} = \frac{100 \text{ mg}}{5} = 20 \text{ mg}$$

WHEN IN DOUBT

As a giver of medications, you share in the health care team's responsibility for making sure that the patient gets the correct dose. To meet this responsibility, you are learning all you can about dosage calculation and conversions between measurement systems. If you study hard and do the practice exercises until you have mastered them, you will be prepared to handle most routine dosage questions. However, you must also recognize your limitations. If you are the least bit confused about a conversion, or if you are unsure about a particular calculation, get some help. Ask the physician, the nurse in charge, or the pharmacist to check your work. There should be no shame in asking for assistance in this area. After all, the main concern is the welfare of the patient. What could be more important than getting the dose right?

ACTIVITY SHEET

#100-001-002

"REVIEW MEASUREMENT AND DOSAGE CALCULATIONS"

A. Select the BEST answer.

1. The range of quantities that can produce therapeutic effects of most drugs is

   A. dosage range.
   B. volume space.
   C. unit dosage.
   D. measurement.

2. The basic unit of weight in this system of measurement is the _____ and the basic unit of volume is the _____.

   A. minim, grain.
   B. grain, minim.
   C. weight, volume.
   D. liquid, dry.

3. The system of measurement described in question 2 is

   A. household.
   B. metric.
   C. dosage.
   D. apothecary.

4. A single formula used to calculate the number tablets or capsules is

   A. $\frac{\text{have}}{\text{want}}$

   B. $\frac{\text{known}}{\text{unknown}}$

   C. $\frac{\text{want}}{\text{have}}$

   D. $\frac{\text{age}}{\text{weight}}$

5. Children need smaller doses of medicine than adults. Two ways to adjust dosages for children is by

   A. known / unknown

   B. want / have

   C. age / weight

6. The more complex formula used to calculate dosages with conversions is

   A. known / unknown

   B. want / have

   C. age / weight

A. Matching.

Choose from Column B the correct answer and place on the space provided in Column A.

Column A	Column B
_____1. apothecary	A. basic unit of wt. in apothecary system
_____2. dram	B. system of measurement
_____3. grain	C. 1, 2, 3, 4 and so on.
_____4. liter	D. basic unit of volume in metric system
_____5. metric	E. 60 grains
_____6. milligram	F. one-thousandth of a gram
_____7. minim	G. basic unit of volume in apothecaries system
_____8. Roman	H. I, II, III, IV, and so forth

INTERMEDIATE OBJECTIVE #2

2. Measure and calculate dosage.

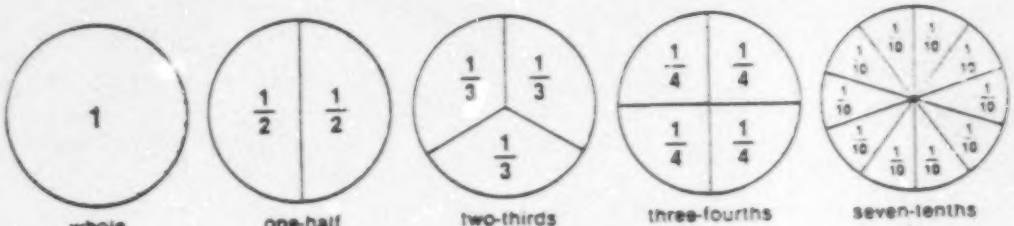
LEARNING STEPS (Activities)	RESOURCES
1. Cosult Resource #1 for a review on basic mathematics.	1. See instructor and Job sheet 100-002-001, pgs. 21 - 27, "Review Basic Math" in this S.L.G.
2. Upon mastery of this basic Math Review, see resource #2 for an introduction to measurement and dosage calculations.	2. See instructor
3. Complete Resource #3 for an exercise on measure and calculate dosage.	3. Job sheet 100-002-003, "Exercise on Measurement and Calculation of dosage," pgs.28-33 in this SLG. See instructor for evaluation.
4. For mastery of this task, complete Resource #4 for a performance evaluation.	4. Performance checklist, pgs. 34-35 in this SLG. See instructor for evaluation.
5. Complete resource #5 for a written evaluation.	5. Written Criterion Exam, Task #100 , "Measure and calculate dosage," in LRC. See instructor for evaluation.
6. Prodeed to Resource #6.	6. See instructor for next learning guide.

JOB SHEET

Math Review: Fractions

Definitions

A fraction is a way of expressing an *amount that is part of a whole*:



whole
1

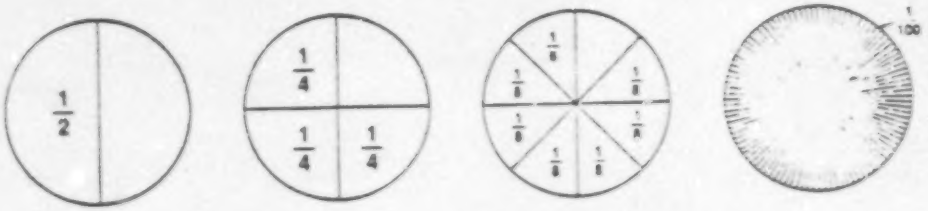
one-half
$\frac{1}{2}$

two-thirds
$\frac{2}{3}$

three-fourths
$\frac{3}{4}$

seven-tenths
$\frac{7}{10}$

The more parts the whole is divided into, the smaller each part has to be:



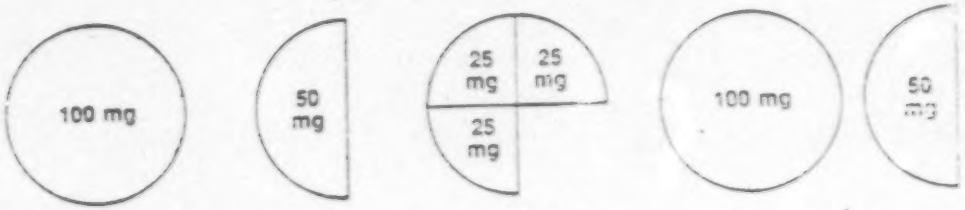
The whole can be a set of things, for example, nine dots or 100 mg:

whole
1

one-third
$\frac{1}{3}$

two-thirds
$\frac{2}{3}$

one and one-third
$1\frac{1}{3}$



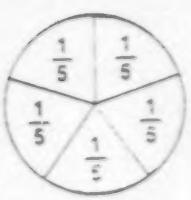
1

$\frac{1}{2}$

$\frac{3}{4}$

$1\frac{1}{2}$

A fractional amount of a whole is expressed like this:



$\frac{3}{5}$ — 3 ← NUMERATOR: how many parts of the whole you are taking

5 ← DENOMINATOR: how many equal parts the whole is divided into

A fraction is also a way of expressing a relationship between two numbers or quantities: for example, $\frac{3}{4}$ means "3 divided by 4" which can also be expressed as:

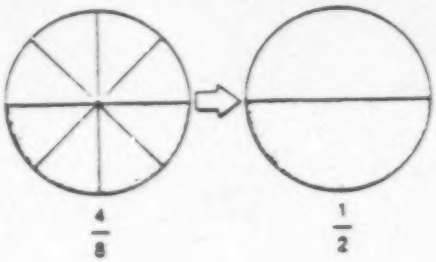
3 – 4 *or* $4\overline{)3}$ *or* 3 : 4 (ratio)

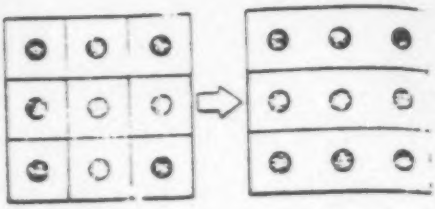
Program	Task	Page

JOB SHEET
#100-002-001

Simplifying fractions

To make calculations easier, fractions may be *reduced to lowest terms*:





To reduce a fraction to lowest terms, *divide* both the numerator and the denominator by the largest number that will go into both of them evenly; for example:

$$\frac{4}{8} = \frac{4 \div 4}{8 \div 4} = \frac{1}{2}, \qquad \frac{6}{9} = \frac{6 \div 3}{9 \div 3} = \frac{2}{3}$$

When you reduce a fraction, the amount stays the same, but the fraction is easier to work with.

(Note: If there is no number that goes into both the numerator and denominator evenly, you cannot reduce the fraction: it is already in lowest terms.)

Canceling is a short-cut way of showing that you have divided the top and bottom of the fraction by the same number. Here is how it is shown in written work:

$\frac{3}{15}$ You wish to reduce $\frac{3}{15}$ to lowest terms, so you divide top and bottom by the largest number that will go into both of them evenly, or 3.

$\frac{\cancel{3}\ 1}{\cancel{15}\ 5}$ Three goes into 3 once, so you cancel out the 3 and write 1.
Three goes into 15 five times, so you cancel out the 15 and write 5.

$\frac{1}{5}$ Thus, after reducing to lowest terms, the fraction is $\frac{1}{5}$.

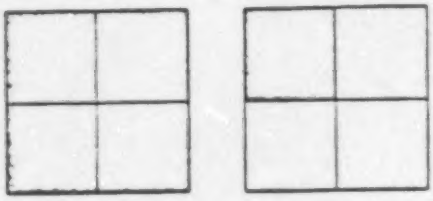
Units of measurement can be canceled, too, as long as the same type of unit appears in both the numerator and the denominator:

$\frac{18\ \cancel{mg}}{25\ \cancel{mg}}$ *or* $\frac{3\ \cancel{gr}}{5\ \cancel{gr}}$ *but not* $\frac{3\ gr}{50\ mg}$

A relationship like $\frac{350\ mg}{25\ mg}$ means the same as 350 mg ÷ 25 mg *or* 25 mg $\overline{)350\ mg}$ *or* 350 mg : 25 mg

JOB SHEET
#100-002-001

To simplify a "top-heavy" fraction (or **improper fraction**) where the numerator is larger than the denominator, turn it into a **mixed number** (whole number and fraction) as follows:



$$\frac{5}{4} = 1\frac{1}{4} \qquad \left(4\overline{)\,5}\ \text{1 rem 1}\right)$$

Divide the numerator by the denominator. Express the remainder as a fraction with the same denominator.

Such top-heavy fractions are changed to mixed numbers *only* in giving the final answer to a problem. During calculations, mixed numbers are awkward to work with and must be changed to improper fractions.

Multiplying fractions

To multiply a fraction by another fraction, multiply *numerator* x *numerator* and *denominator* x *denominator* (x = *times*)

$$\frac{3}{10} \times \frac{1}{10} = \frac{3 \times 1}{10 \times 10} = \frac{3}{100}$$

$$\frac{5}{8} \times \frac{2}{3} = \frac{5 \times 2}{8 \times 3} = \frac{10}{24}$$

Remember to reduce the answer to lowest terms.

$$\frac{\cancel{10}^{\,5}}{\cancel{24}_{\,12}} = \frac{5}{12}$$ (divided top and bottom by 2)

To multiply a fraction by a whole number multiply *whole number* x *numerator*

$$\frac{7}{9} \times 2 = \frac{7}{9} \times \frac{2}{1} = \frac{14}{9} = 1\frac{5}{9}$$

(You may express the whole number as a fraction by placing it the denominator "1". Then place the product over the denominator and simplify.

Program	Task	Page
07.0905	100	22

JOB SHEET
#100-002-001

In multiplying fractions, you are allowed to cancel *across* the times sign as follows:

$$\frac{3}{\cancel{4}_{1}} \times \frac{\cancel{4}^{1}}{5} = \frac{3 \times 1}{1 \times 5} = \frac{3}{5}$$

$$\frac{\cancel{8}^{4}}{9} \times \frac{5}{\cancel{14}_{7}} = \frac{4 \times 5}{9 \times 7} = \frac{20}{63}$$

You divide the denominator of one fraction and the numerator of the opposite fraction by the same number. This makes your job easier because you work with smaller numbers.

In the same way, you may cancel identical units of measurement across the times sign. This is important for certain formulas in dosage calculation:

$$2 \cancel{\text{tsp}} \times \frac{5 \text{ ml}}{1 \cancel{\text{tsp}}} = 10 \text{ ml}$$

$$\cancel{7.5}^{.5} \cancel{\text{gr}} \times \frac{1 \text{ g}}{\cancel{15}_{1} \cancel{\text{gr}}} = 0.5 \text{ g}$$

Dividing fractions

Flip over (invert) the divisor and then *multiply* the two fractions:

$$\frac{1}{2} \div \overset{\text{invert}}{\downarrow} \frac{2}{3} = \frac{1}{2} \times \frac{3}{2} = \frac{3}{4}$$

$$\frac{5}{8} \div \frac{5}{9} = \frac{\cancel{5}^{1}}{8} \times \frac{9}{\cancel{5}_{1}} = \frac{9}{8}$$

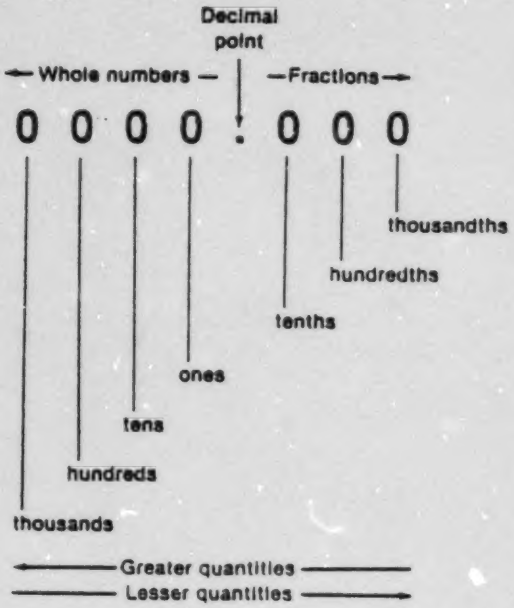
$$\frac{4}{5} \div 3 = \frac{4}{5} \times \frac{1}{3} = \frac{4}{15}$$

JOB SHEET
#100-002-001

Decimal fractions

In working with metric measures, fractions are expressed as decimals. Here is how the decimal system works:

The placement of numbers in relation to the decimal point tells their value. All the place values are multiples of ten.



Here are some examples of various whole numbers and fractions expressed as decimals:

$1.0 \rightarrow 1\frac{0}{10} \rightarrow 1$

$0.75 \rightarrow \frac{75}{100} \rightarrow \frac{3}{4}$

$0.66 \rightarrow \frac{66}{100} \rightarrow \frac{2}{3}$

$0.5 \rightarrow \frac{5}{10} \rightarrow \frac{1}{2}$

$0.33 \rightarrow \frac{33}{100} \rightarrow \frac{1}{3}$

$0.25 \rightarrow \frac{25}{100} \rightarrow \frac{1}{4}$

$0.125 \rightarrow \frac{125}{1000} \rightarrow \frac{1}{8}$

JOB SHEET

As you see above, any decimal fraction can be expressed as a regular or common fraction. Note the position of the final digit relative to the decimal point:

$$0.48 \rightarrow \frac{48}{100} \rightarrow \frac{\overset{12}{\cancel{48}}}{\underset{25}{\cancel{100}}} \rightarrow \frac{12}{25}$$

hundredths

$$1.6 \rightarrow 1\frac{6}{10} \rightarrow 1\frac{\overset{3}{\cancel{6}}}{\underset{5}{\cancel{10}}} \rightarrow 1\frac{3}{5}$$

tenths

Any common fraction can be changed to a decimal fraction by dividing the numerator by the denominator:

$$\frac{1}{3} \rightarrow 3\overline{)1.00}\ 0.333,\text{etc.} \rightarrow 0.33$$

9
10
9
1

To multiply decimal fractions:

$$1.5 \times 0.35 = ?$$

Set up your multiplication like a normal multiplication problem:

$$\begin{array}{r} 1.5 \\ \times 0.35 \\ \hline 75 \\ 45 \\ \hline 0.525 \end{array}$$

To decide where the decimal point goes, look at the original problem and count the total number of places shown to the right of the decimal point, in this case 3.

$$\underset{1}{1.5} \times \underset{2\,3}{0.35} = \underset{3\,2\,1}{0.525}$$

Then, starting from the last digit of the answer, count that many places to the left and place the decimal right after that digit.

More examples:

$$100 \times \underbrace{0.01}_{1\,2} = \underbrace{1.00}_{2\,1}$$

$$\underbrace{3.25}_{1\,2} \times \underbrace{0.002}_{3\,4\,5} = \underbrace{0.00650}_{5\,4\,3\,2\,1}$$

$$\underbrace{2.5}_{1} \times \underbrace{1.4}_{2} = \underbrace{3.50}_{2\,1}$$

Placing the decimal point correctly is *very* important. A misplaced decimal means a huge error in dosage calculation.

Divide decimal fractions as follows:

$$30 \div 1.5 = ?$$

If there is a decimal fraction in the divisor, move it to the right past the rightmost digit, making the divisor a whole number. Count how many places you moved it. Then move the decimal in the dividend the same number of places to the right. The decimal should be placed directly above that point in the quotient (answer).

$$\begin{array}{r} 2\,0. \leftarrow \text{quotient} \\ \text{divisor} \rightarrow 1.5\overline{)30.0} \leftarrow \text{dividend} \end{array}$$

If there is no decimal fraction in the divisor, the quotient gets a decimal point directly above the one in the dividend:

$$\begin{array}{r} 2.0 \\ 15\overline{)30.0} \end{array}$$

JOB SHEET #100-002-003

"EXERCISES ON MEASUREMENT AND CALCULATION OF DOSAGE"

Exercises

A. Write abbreviations for these units of measurement.

1. minim _____
2. grain _____
3. dram _____
4. fluidram _____
5. ounce _____
6. drops _____
7. pint _____
8. teaspoon _____
9. tablespoon _____
10. pound _____
11. milligram _____
12. milliliter _____
13. cubic centimeter _____
14. liter _____
15. gram _____

B. Practice decoding abbreviations. The following dosage orders are given using Roman numerals and abbreviations for the apothecaries' system of measurement. Write them out in full, using arabic numerals.

1. ʒ iv _____
2. gr lss _____
3. fʒ viii _____
4. m ii _____
5. fʒ ix _____

C. Practice with measurement systems. Use Tables 4-4, 4-6, and 4-7 to find the equivalents. See how many you can memorize.

1. A grain weighs the same as _____ minim(s) of liquid.
2. One minim is the same as _____ drop(s).
3. One milliliter is approximately equal to _____ drop(s).
4. Fifteen grains is about _____ gram(s).
5. One grain is about _____ milligram(s).
6. One gram is equal to _____ milligrams.
7. One milliliter is the same as _____ cubic centimeter(s).
8. One teaspoon is about _____ milliliter(s).
9. One-half of a gram equals _____ milligram(s).
10. One glass (8 oz) contains about _____ milliliter(s).
11. One milligram is about _____ grain.
12. One-tenth of a milligram is about _____ grain.
13. One liter (1000 cc) is about _____ quart(s).

D. Reduce these fractions to lowest terms.

1. $\frac{4}{8}$ =
2. $\frac{3}{9}$ =
3. $\frac{50}{100}$ =
4. $\frac{24}{32}$ =
5. $\frac{21}{28}$ =
6. $\frac{250}{1000}$ =
7. $\frac{12}{18}$ =
8. $\frac{25}{45}$ =
9. $\frac{225}{500}$ =
10. $\frac{36}{48}$ =
11. $\frac{18}{36}$ =
12. $\frac{15}{60}$ =

E. Change these improper fractions to mixed numbers.

1. $\frac{8}{3}$ =
2. $\frac{5}{2}$ =
3. $\frac{17}{12}$ =
4. $\frac{55}{20}$ =
5. $\frac{18}{4}$ =
6. $\frac{68}{3}$ =
7. $\frac{350}{100}$ =
8. $\frac{27}{5}$ =
9. $\frac{60}{15}$ =
10. $\frac{83}{20}$ =
11. $\frac{45}{7}$ =
12. $\frac{600}{60}$ =

JOB SHEET #100-002-003

F. Multiply these fractions. Reduce the answers to lowest terms.

1. $\frac{3}{10} \times \frac{1}{10} =$
2. $\frac{5}{8} \times \frac{2}{3} =$
3. $2 \times \frac{5}{8} =$
4. $\frac{5}{4} \times \frac{7}{6} =$
5. $\frac{11}{12} \times 3 =$
6. $7 \times \frac{2}{5} =$
7. $\frac{3}{4} \times \frac{4}{5} =$
8. $\frac{8}{9} \times \frac{5}{14} =$
9. $\frac{4}{9} \times \frac{4}{5} =$
10. $250 \text{ mg} \times \frac{1 \text{ gr}}{60 \text{ mg}} =$
11. $3 \text{ gr} \times \frac{60 \text{ mg}}{1 \text{ gr}} =$
12. $45 \text{ gr} \times \frac{1 \text{ g}}{15 \text{ gr}} =$

G. Divide these fractions. Reduce the answers to lowest terms.

1. $\frac{1}{2} \div \frac{2}{3} =$
2. $\frac{5}{8} \div \frac{5}{9} =$
3. $\frac{1}{60} \div 3 =$
4. $\frac{1}{60} \div \frac{1}{2} =$
5. $\frac{1}{12} \div \frac{3}{24} =$
6. $2 \div \frac{4}{15} =$
7. $1 \div \frac{1}{600} =$
8. $\frac{1}{60} \div \frac{1}{12} =$
9. $\frac{2}{6} \div \frac{3}{12} =$
10. $\frac{3}{8} \div \frac{5}{8} =$
11. $\frac{\frac{2}{15}}{\frac{1}{60}}$
12. $\frac{\frac{3}{5}}{\frac{2}{3}}$

H. Write these as decimal fractions:

1. $\frac{1}{2} =$
2. $\frac{1}{3} =$
3. $\frac{1}{4} =$
4. $\frac{2}{3} =$
5. $\frac{3}{4} =$
6. $\frac{6}{10} =$
7. $\frac{2}{5} =$
8. $\frac{12}{100} =$
9. $\frac{25}{100} =$
10. $\frac{89}{100} =$
11. $\frac{23}{1000} =$
12. $\frac{225}{1000} =$
13. $1\frac{2}{10} =$
14. $3\frac{3}{4} =$
15. $5\frac{78}{1000} =$

JOB SHEET #100-002-003

I. Write these as common fractions and reduce to lowest terms.

1. 0.75 =
2. 0.2 =
3. 0.33 =
4. 1.5 =
5. 23.02 =
6. 5.66 =
7. 0.25 =
8. 0.005 =
9. 0.375 =

J. Practice with decimal fractions:

1. $1.5 \times 3 =$
2. $1.5 \times 0.3 =$
3. $1.5 \times 0.03 =$
4. $2.75 \times 0.1 =$
5. $7.5 \div 25 =$
6. $7.5 \div 2.5 =$
7. $7.5 \div 0.25 =$
8. $4 \div 0.4 =$
9. $\frac{1.2}{0.03} \div \frac{2}{3} =$
10. $2.25\ g \times \frac{15\ gr}{1\ g} =$
11. $3.2\ L \times \frac{1000\ cc}{1\ L} =$
12. $0.5\ ml \times \frac{15\ m}{1\ ml} =$

K. Change from grams to milligrams:

1. 0.1 g = _____ mg
2. 2.5 g = _____ mg
3. 0.03 g = _____ mg
4. 0.125 g = _____ mg
5. 3.45 g = _____ mg

L. Change from milligrams to grams:

1. 325 mg = _____ g
2. 1200 mg = _____ g
3. 3000 mg = _____ g
4. 5 mg = _____ g
5. 75 mg = _____ g

M. Use Table 4-7 if necessary to convert these dosages. But first try to do them in your head.

1. 0.1 mg = _____ gr
2. 0.5 mg = _____ gr
3. _____ mg = $\frac{1}{100}$ gr
4. 4 mg = _____ gr
5. _____ mg = 1 gr
6. 150 mg = _____ gr
7. _____ mg = 5 gr
8. 1 g = _____ gr
9. _____ g = 7½ gr
10. 3 g = _____ gr

JOB SHEET #100-002-003

N. Use the WANT/HAVE formula to solve these dosage problems:

1. The doctor orders 250 mg of a drug. You have 100-mg scored tablets on hand. You will give the patient _____ tablets.
2. The medication order calls for a dose of 1¼ gr aspirin. Aspirin comes in scored tablets of 5 gr each. You will give the patient _____ tablet. (*Hint:* 1¼ = 5/4)
3. The physician orders 75 mg of a drug. You have capsules of 25 mg each. You give the patient _____ capsules.
4. An injectable antibiotic is packaged 100,000 units/cc. The doctor orders 400,000 units. A certified nurse will administer _____ cc to the patient parenterally.
5. A solution contains 25 mg of a drug per teaspoon. The doctor ordered 50 mg. You give _____ tsp.
6. You have ½-gr tablets. You want to give ¼ gr. You administer _____ tablet(s).
7. The doctor's order says to give gr xv. The medicine bottle says each 5-ml teaspoon contains 7½ gr. You give _____ tsp. (*Hint:* 7½ gr = 15/2 gr.)

O. Use the KNOWN/UNKNOWN formula or Table 4–7 to solve these dosage problems involving conversions:

1. The doctor orders 600 mg. The dosage form on hand is gr x tablets. You give _____ tablet(s). (*Hint:* Find 600 mg = ? gr, then use the WANT/HAVE formula.)
2. You have ¼-gr tablets on hand, and the doctor has ordered 15 mg of the drug. You give _____ tablet(s).
3. The doctor ordered ¾ gr. The tablets on hand contain 30 mg each. You give _____ tablet(s). (*Hint:* Find ¾ gr = ? mg, then use the WANT/HAVE formula.)
4. An order is for 45 minims of a drug, but you do not have a measuring container marked in minims. You do have a container marked in milliliters. You administer _____ ml.

P. Practice with dosage calculations: translate each medication order and then answer the dosage questions:

1. An order reads: Hydephen f℥ i t.i.d. (p.o.) × 5 days.
   a. You do not have a glass container marked in fluidounces. What household measure could you use? _____
   b. How many tablespoons are there in f℥ i (f℥ i = ? T)? _____
   c. How many fluidounces do you need for a 1-day supply of Hydephen? _____
   d. How many fluidounces of Hydephen are needed in 5 days? _____
   e. How many pints do you order from the pharmacy to have a 5-day supply of Hydephen (15 f℥ = ? pt)? _____
2. An order reads: Fer-In-Sol 18 mg q.d. p.o. One teaspoon supplies 18 mg of iron. The pharmacy sends up an 8-oz bottle of Fer-In-Sol.
   a. How many teaspoons are there in an 8-oz. bottle (8 oz = ? tsp)? _____
   b. About how many days will the bottle of Fer-In-Sol last? _____

Q. Practice calculating dosages for children. The usual adult dose of Dilantin is 100 mg.

1. How much Dilantin would you give to a child 9 months old? _____
2. How much Dilantin would you give to a child who weighs 34 lb? _____
3. How much would you give to a 10-year old? _____
4. How much would you give to a 16-year old? _____

R. Extra practice with conversions.

1. How many grams would you give if the order is 10 mg of Valium? _____
2. How many cubic centimeters do you give when the order is 2 L of Ringer's lactate? _____
3. How many tablespoons would you give if the order is 8 oz of Gelusil? _____
4. How many drops do you give when the order is ½ tsp? _____
5. How many milligrams of phenobarbital would you give if the order was for 2 gr? _____
6. You have capsules containing 0.5 g of a drug. The doctor ordered 500 mg. How many capsules do you give? _____

PERFORMANCE/PRODUCT CHECKLIST

Program: MEDICAL ASSISTING

Task No: 100

Student's Name: _____ Date Of Attempt: _____

Evaluator's Name: _____ Evaluation Site: _____

Performance Attempt: 1 2 3 4

Terminal Performance Objective:

Given the necessary tools and equipment, measure and calculate dosage.

Directions To The Student:

Before attempting this task for mastery, carefully review this checklist. You will be evaluated on the basis of this checklist. When you feel you are ready for evaluation, contact your instructor. You must complete your performance within 10 minutes and must score at least 4 out of 5 points or 90 % for mastery. Critical items are marked with an asterisk (*). These items must be satisfactorily completed.

Directions To The Evaluator:

The student will contact you when ready for the evaluation. The student must complete the performance within 10 minutes and must score 4 out of 5 points or 90 % and all items marked with an asterisk (*) must be satisfactorily completed.

CRITICAL ITEMS	ITEMS TO BE OBSERVED OR CHECKED	RATING	
		YES	NO
*	1. Solve the WANT/HAVE problem.		
*	2. Solve the KNOWN/UNKNOWN problem.		
*	3. Calculate the problem given on the dosage for a child.		
	4. Calculate the problem with a conversion		
*	5. Translate the medication order.		

TOTAL POINTS EARNED =

POINTS NEEDED FOR MASTERY = 4
TOTAL POINTS POSSIBLE = 5

PROGRAM Medical Assisting

CRITERION EXAM

TASK # 100

DIRECTIONS:

THE PURPOSE OF THIS EXAM IS TO DETERMINE WHETHER OR NOT YOU HAVE UNDERSTOOD THE INFORMATION ON ~~Measuring and Calculating Dosage~~

Each of the questions or incomplete statements below is followed by several words, phrases, or a series of numbers. Choose the one which best answers the question or completes the statement correctly. Place the letter associated with that choice (A,B,C or D) in the numbered blank space on your ANSWER SHEET. DO NOT WRITE ON THIS TEST!!! To master this exam you must answer 9 out of 10 items correctly, 90 %.

Program	Task	Page
07.0904	100	36

EVALUATION SHEET

WRITTEN CRITERION EXAM Task #100
"MEASURE AND CALCULATE DOSAGE"

Select The Best Answer.

1. A_____ is the basic unit of weight in the apothecary system measurement.

   A. Grain
   B.
   C. Gram
   D. Dram

2. Feet, inches, miles, pints, quarts prounds and so on are measurements of the _____system.

   A. Apothecary
   B. Household
   C. Metric
   D. Pharmaceutical

3. One grain is evuivalent to _____ milligrams (____ mg.)

   A. 1/600
   B. 1/60
   C. 1
   D. 60

4. Fifteen grains (15 gr) is equivalent to _____ gram (_____ g).

   A. 0.1
   B. 0.01
   C. 0.15
   D. 1

5. If you know that 1 gr is equivalent to about 60 mg, then logically 5 gr is about 300 mg. and 1/4 gr is about _____ mg.

   A. 5
   B. 10
   C. 15
   D. 60

6. The doctor orders 350 mg to be given once a day. All you have on hand are 100mg tablets. How many tablets should you give? (Show steps in solving problem).

   A. 3 tablets
   B. 3 and 1/2 tablets
   C. 4 tablets
   D. 4 and 1/2 tablets

EVALUATION SHEET

7. You are to give a patient 6 tsp. of milk of magnesia as necessary for constipation. How many tablespoons would that be? (Show steps in solving problem).

   A. 1 T.
   B. 2 T.
   C. 3 T.
   D. 4 T.

8. Suppose that you were giving tetracyclive to an 8 year old child. Eight years is the same as 96 months (8 X 12= 96) (Show Calculations).

   A. 16 mg.
   B. 160 mg.
   C. 600 mg.
   D. 1600 mg.

9. A doctor orders dilantin for a 30 lb. child. The usual adult dose is 100 mg. (Show calculations).

   A. 2 mg.
   B. 20 mg.
   C. 200 mg.
   D. 1200 mg.

10. Convert simply 0.25 to milligrams.

    A. 25 mg.
    B. 250 mg.
    C. 0.5 mg.
    D. 1000 mg.

LAKE COUNTY AREA VOCATIONAL CENTER

COMPETENCY-BASED INDIVIDUALIZED VOCATIONAL EDUCATION INSTRUCTION

STUDENT LEARNING GUIDE

Produced By ROSEMARIE MEYER, RN, CMA Date 11/84

TASK: PERFORM RETICULOCYTE COUNT

PURPOSE:

The reticulocyte count is an important diagnostic tool. It is a relatively accurate reflection of the amount of effective red cell production taking place in the bone marrow. This learning guide will assist you to perform a reticulocyte count.

MEDICAL ASSISTING

Program	Task	Est.Time	Prereq.
07.0904	128	10 hrs	

edk

LEARNING CONTRACT (optional)

1. STUDENT DATA

NAME _____ SOCIAL SECURITY NUMBER _____

LENGTH OF CONTRACT (NORMAL TIME IN HOURS) 10 hrs

2. TERMINAL PERFORMANCE OBJECTIVE

Given the necessary reagents and equipment, perform a reticulocyte count. To master this task you must score 17 out of 18 (90%) on a performance evaluation and 9 out of 10 (90%) on a written criterion examination.

2a. INTERMEDIATE OBJECTIVE(s)

1. Describe reticulocyte count.
2. Perform reticulocyte count.

3. AGREEMENT

I, _____ agree to complete the above stated terminal performance requirement within _____ to _____. I further recognize that the conditions of the contract (performance and time agreement) report my ability to perform the requirements of the occupation and record my progress.

_____ Student's Signature

_____ Instructor's Signature (verifies competency)

Program	Task	Page
07.0904	128	1

INTERMEDIATE OBJECTIVE #1

Describe reticulocyte count.

LEARNING STEPS (Activities)

1. Read Resource #1 for information on reticulocyte count.

2. Complete Resource #2 for a review on reticulocyte count.

3. Proceed to Resource #3.

RESOURCES

1. Information Sheet 128-001-001, "Reticulocyte Count," pages in this SLG. * Information taken from textbook: Hematology: Principles and Procedure, by Barbara Brown, 3rd edition, pages 95-100.

2. Job Sheet 128-001-002, "Review Reticulocyte Count," pages 9 - 11 in this SLG.

   See instructor for evaluation.

3. Intermediate Objective #2, page 12 in this SLG.

RETICULOCYTE COUNT

The red blood cell goes through six stages of development: rubriblast, prorubricyte, rubricyte, metarubricyte, reticulocyte, and mature red blood cell. The first four stages are normally confined to the bone marrow. The reticulocyte, however, is found in both the bone marrow and peripheral blood. In the bone marrow, it spends approximately 2 days maturing and is then released to the blood, where it matures for another day, prior to becoming a mature red blood cell.

The reticulocyte count is an important diagnostic tool. It is a relatively accurate reflection of the amount of effective red cell production taking place in the bone marrow. Since the life span of a red blood cell is 120 days, ±20 days, the bone marrow replaces approximately 1% of the adult red blood cells every day. The normal values for a reticulocyte count are, therefore, 0.5% to 1.5%. The reticulocyte count is expressed as the number of reticulocytes present, per 100 red blood cells (in %). A decreased reticulocyte count is found in aplastic anemia and in conditions in which the bone marrow is not producing red blood cells. Increased reticulocyte counts are found in hemolytic anemias, iron deficiency anemias receiving iron therapy, thalassemia, sideroblastic anemia, and acute and chronic blood loss.

Corrected Reticulocyte Count. An accurate reticulocyte count should reflect the total production of red cells regardless of the concentration of red cells in the blood (red blood count). As an example, compare the following two patients. Patient No. 1 has a hematocrit of 42% and a reticulocyte count of 1.0%. Patient No. 2 has a hematocrit of 21% and a reticulocyte count of 2.0%. Patient No. 2, theoretically, has half as many red cells as patient No. 1 but has the same number of reticulocytes as patient No. 1 because the reticulocytes are diluted by only half the number of red cells, as in patient No. 1. To compensate for this, a corrected reticulocyte count is calculated, based on a normal hematocrit of 42% for women and 45% for men. The formula for this correction follows.

$$\text{Corrected reticulocyte count in \%} = \frac{\text{Patient's hematocrit}}{\text{Normal hematocrit}} \times \text{Reticulocyte count in \%}$$

In addition to correcting a reticulocyte count for an abnormally low hematocrit, consideration is also given to the presence of marrow reticulocytes present in the peripheral blood. In this circumstance, the reticulocyte production index is calculated. As previously stated, the reticulocytes spend approximately 2 days in the bone marrow before being released into the blood. In certain situations, these marrow reticulocytes are released directly into the blood, prior to maturation in the marrow. This is detected by nucleated red blood cells and/or polychromatophilic macrocytes ("shift" cells) present in the circulating blood. To correct for this reticulocyte maturation delay, the reticulocyte production index is calculated by dividing the corrected reticulocyte count by two. In patients showing no nucleated red cells or "shift" cells, the corrected reticulocyte count is divided by one (normal reticulocyte maturation time) and the reticulocyte production index is equal to the corrected reticulocyte count.

In conditions of anemia, the bone marrow normally shows a response to this anemia by increasing red cell production. At the same time, the reticulocyte count in the blood also is increased. See Table 3 for the normal bone marrow response to a decreased hematocrit.

TABLE 3. NORMAL BONE MARROW RESPONSE TO ANEMIA

HEMATOCRIT	RETICULOCYTE COUNT	CORRECTED RETICULOCYTE COUNT
45	1.0%	1.0%
35	8.5%	2–3%
25	14.0%	3–5%
15	24.0%	3–5%

REAGENTS AND EQUIPMENT

1. Reticulocyte stain. Any of the following staining solutions may be employed:
   A. New methylene blue N solution

Sodium chloride	0.8 g
Potassium oxalate	1.4 g
New methylene blue N	0.5 g
Distilled water	100 ml

   B. Brilliant cresyl blue solution

Brilliant cresyl blue	1.0 g
Sodium chloride, 0.85% (w/v)	99 ml

   Filter both of the preceding staining solutions prior to use.
2. Glass slides.
3. Applicator sticks or microhematocrit tubes.
4. Microscope.

SPECIMEN

Whole blood (1 ml), using EDTA, heparin, or ammonium-potassium oxalate as the anticoagulant. Capillary blood from the finger, toe, or heel may also be used.

PRINCIPLE

After the metarubricyte loses its nucleus, a small amount of RNA remains in the red cell, and the cell is known as a reticulocyte. To detect the presence of this RNA, the red cells must be stained while they are still living. This process is called *supravital staining*. After the cells have been stained by either new methylene blue N or brilliant cresyl blue, the number of reticulocytes in 1,000 red cells is determined. This number is divided by ten in order to obtain the reticulocyte count in percent.

PROCEDURE

1. Place three drops of filtered reticulocyte stain in a small test tube.
2. Add three drops of blood to the test tube containing the stain. (Ensure that the blood specimen is well mixed.)
3. Mix the tube contents and allow to stand for a minimum of 15 minutes, or incubate specimen at 37°C for 15 minutes. This allows the reticulocytes adequate time to take up the stain.
4. At the end of 15 minutes, mix the contents of the tube well.
5. Using applicator sticks, or a microhematocrit tube, place a drop of the mixture on each of three slides and make smears.
6. Stain with Wright's stain, using the same method as previously described for routine blood smears. (This step is not necessary and may be omitted. See step No. 9, below, for explanation.)
7. Allow smears to air-dry.
8. Place the first slide on the microscope stage and, using the low power objective (10 ×), find an area in the thin portion of the smear in which the red cells are evenly distributed and are not touching each other. Carefully change to the oil immersion objective (100 ×) and further locate an area in which there are approximately 100 to 200 red cells per oil immersion field.
9. As soon as the proper area is selected, the reticulocytes may be counted. If the smear has not been counterstained with Wright's stain, the red cells are a light to medium green in color. The RNA present in the reticulocytes stains a deep blue. When counterstaining with Wright's stain, the red cells are pink, whereas the RNA in the reticulocytes stains a deep purple. The reticulum may be abundant or sparse, depending upon the cell's stage of development. The youngest reticulocyte shows a larger amount of RNA (Fig. 112), whereas the more mature reticulocyte shows only a small amount of RNA (Fig. 112C). Count all of the red blood cells in the first field on one cell counter. At the same time enumerate the

FIG. 112. Stages of maturation in the reticulocyte.

reticulocytes (Fig. 113) in the same field with a second cell counter. Move the slide as described for the differential count until all reticulocytes in 1000 red cells have been counted.

10. A second technologist should repeat the reticulocyte count in the same manner as described in step 9 on the second reticulocyte smear. The two results should agree within ±10% of each other. If they do not, repeat the reticulocyte count on the third smear.
11. Average the two results and calculate the reticulocyte count as shown below.

$$\% \text{ Reticulocytes} = \frac{\text{Number of reticulocytes counted in 1000 red cells}}{10}$$

12. Calculate the corrected reticulocyte count. If marrow reticulocytes or nucleated red blood cells are present, also calculate the reticulocyte production index.

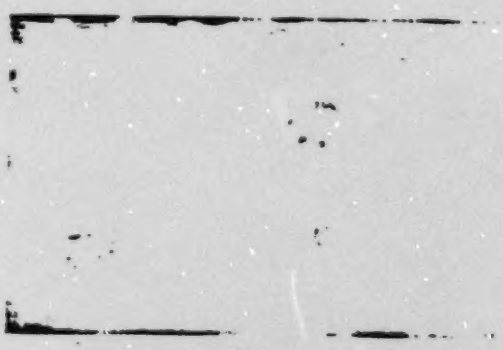


FIG. 113. Reticulocytes. (Supravital staining of the red blood cells with new methylene blue N.) (Magnification × 1000.)

DISCUSSION

1. There are various methods in use for mixing the stain and blood for a reticulocyte count: (1) A microhematocrit tube is a third filled with blood, to which is added an equal amount of stain. This mixture is rotated back and forth in the hematocrit tube, allowed to stand for 15 minutes, remixed, placed on slides, and smears made. (2) Blood is drawn up to the 1.0 mark in the white cell pipet. Wipe off the outside of the pipet and, in order to have a space at the tip of the pipet, allow the blood to run up a short distance into the pipet bulb. Draw stain up to the 1.0 mark. Remove the tip of the pipet from the bottle of stain and draw the stain up into the bulb of the pipet to mix with the blood. (The bulb of the pipet is not full, but contains an equal volume each of blood and stain.) Mix the contents of the pipet, allow to stand for 15 minutes, remix, and make smears.
2. The blood-to-stain ratio does not have to be exactly equal. For best results, a larger proportion of blood should be added to the stain when the patient's hematocrit is low. Add a smaller amount of blood to the stain when the patient has an unusually high hematocrit.
3. The time allowed for staining of the reticulocytes is not critical. It should, however, never be less than 10 minutes.
4. It is extremely important that the blood and stain be mixed well prior to

making smears. The reticulocytes have a lower specific gravity than mature red cells and therefore settle on top of the red cells in the mixture.

5. Each clinical laboratory may show slight alterations in the reticulocyte method, but all are based on the same general principles as described here. Also, corrections for the hematocrit are not carried out in all laboratories.
6. Red cells are frequently noted on the reticulocyte smear that contain areas that are highly refractile. These cells should not be confused with reticulocytes. This condition is probably due to moisture in the air and poor drying of the smear.
7. The presence of high concentrations of glucose in the blood causes the reticulocytes to be poorly stained.
8. New methylene blue N is preferred to brilliant cresyl blue as a reticulocyte stain due to the inconsistent staining properties of the latter.
9. The range of error in the reticulocyte count varies, depending on the number of reticulocytes counted. Using the previously outlined procedure, there is an error of approximately ±25% in the reticulocyte counts within the normal range. This decreases to ±10% in a reticulocyte count of 5%, and decreases even further as the uncorrected reticulocyte count increases.
10. There are several methods of counting reticulocytes once the smears have been made: (1) One procedure utilizes the Miller disc that is placed inside the microscope eyepiece. This disc consists of two squares as shown in Figure 115. The area of the smaller square (B) is a tenth that of square A. Therefore, if there are 40 red cells in square A, there should be four red cells present in square B. When employing this method to count reticulocytes, the red cells in square B are counted in successive fields on the slide, until a total of 500 red cells have been counted. At the same time, the reticulocytes in square A are enumerated. At the completion of the count, theoretically, the reticulocytes contained in 5000 red cells have been counted. The number of reticulocytes obtained in this way is divided by 50, in order to obtain the percent reticulocytes present in the blood. The count is also performed in duplicate, using a second smear, and the results averaged to obtain the test value. This method is somewhat time-consuming. (2) Place a small "window" in the eyepiece of the microscope. This makes the field smaller and the counting of cells easier. (Cut out a round piece of paper the same diameter as the eyepiece and cut a square hole in the center. Unscrew the top lens of the eyepiece, insert the paper, and replace the top lens.) (3) For reticulocyte counts less than 10%, count at least 100 reticulocytes (except in extremely low counts where this would not be practical). Instead of counting the number of red cells in every field, count the red cells in every 8 to 10 fields and also keep track of the number of fields examined. Calculate the reticulocyte count as follows:

$$\frac{\text{Total number of RBCs counted}}{\text{Number of fields in which RBCs were counted}} \times \text{Total number of fields examined} = \text{Total number of RBCs examined}$$

$$\% \text{ Reticulocytes} = \frac{\text{Number of reticulocytes counted}}{\text{Total number of RBCs examined}} \times 100$$

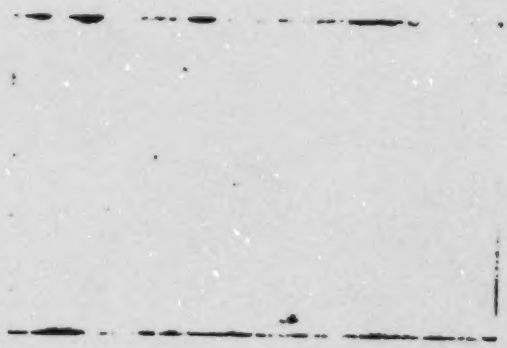


FIG. 114. Heinz bodies. (Supravital staining of red blood cells with new methylene blue N. Compare with reticulocytes stained similarly.) (Magnification × 1000.)

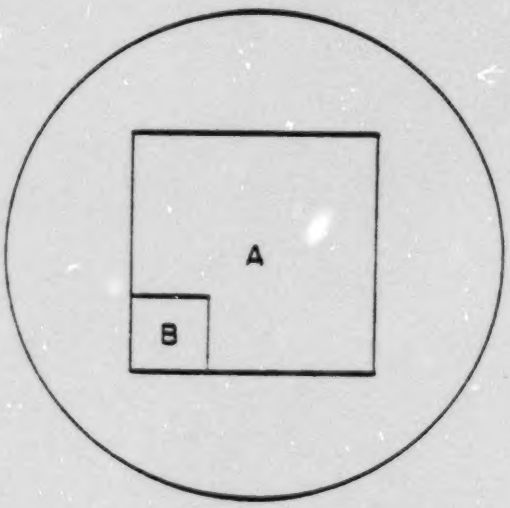


FIG. 115. Miller disc.

11. There are several red cell inclusions that are stained by the new methylene blue N and brilliant cresyl blue stains, in addition to the RNA of the reticulocytes. Howell-Jolly bodies appear as one, sometimes two, round, deep-purple-staining structures. Heinz bodies stain a light blue-green and are usually present at the peripheral edge of the red cell (Fig. 114). Pappenheimer bodies are most often confused with reticulocytes and are the most difficult to distinguish from reticulocytes. These purple-staining iron deposits generally appear as several granules in a small cluster. If Pappenheimer bodies are suspected, a Wright-stained smear may be examined to verify their presence.

JOB SHEET

128-001-002

"Review Reticulocyte Count"

1. The first four stages of development of RBC, the rubriblase, prorubricyte, rubricyte, and metarubricyte are normally continued to

   A. peripheral blood.
   B. bone marrow.
   C. capillary blood.
   D. cell morphology.

2. The _____ is found in both the bone marrow and peripheral blood.

   A. white blood cell
   B. reticulocyte
   C. erythrocyte
   D. mature RBC

3. The bone marrow replaces 1% of the adult red blood cells every day. The normal values for a reticulocyte count, therefore,

   A. 0.15% - 0.5%.
   B. 0.5% - 1.0%.
   C. 0.5% - 1.5%.
   D. 1.5% - .50%.

4. The reticulocyte count is expressed as the number of reticulocytes present, per _____ RBS's (in %).

   A. 10
   B. 50
   C. 100
   D. 1000

5. A decreased reticulocyte count is found in conditions in which the bone marrow is not producing red blood cells and

   A. aplastic anemia.
   B. pernicious anemia.
   C. iron-deficiency anemia.
   D. hemolytic anemia.

6. To correct for a reticulocyte naturation delay, the reticulocyte production index is calculated by dividing the corrected reticulocyte count by

   A. one.
   B. two.
   C. ten.
   D. fifty.

7. _____cells are indicative of increased red cell production and appear somewhat larger than normal circulating red cells and are polychromatophilic.

   A. Macrocytes
   B. Microcytes
   C. Hematopoietic
   D. "Shift"

8. Compare the following patients.

   Pt. 1 HCT 42% Reticulocyte count 1.0%

   Pt. 2 HCT 21% Reticulocyte count 2.0%

   Patient #2, theoretically, has half as many red cells as patient #1, but has has the same number of reticulocytes as patient #1 because the reticulocytes are diluted by only half the number of red cells, as in patient #1.

   To compensate for this, a _____ _____ count is calculated, based on a normal hematocrit of 42% for woemn and 45% for men.

   A. complete blood
   B. corrected reticulocyte
   C. production index
   D. marrow reticulocyte

9. EDTA, Heparin, or ammonium-potassium oxalate are

   A. anticoagulants.
   B. red blood cells.
   C. staining solutions.
   D. reagents.

10. After the reticulocytes are stained, the number of reticulocytes in 1,000 red cells is divided by _____ in order to obrain the reticulocyte count in percent.

A. one
B. two
C. five
D. ten

11. The time allowed for staining of the reticulocytes is not critical, however, it should never be less than _____ minutes.

A. one
B. two
C. five
D. ten

12. The blood and stain is t be well mixed prior to making smears. Reticulocytes have a _____ specific gravity than mature red cells and therefore settle _____ of the red cells in the mixture.

A. low, top
B. high, bottom
C. low, bottom
D. high, top

13. High concentrations of _____ in the blood causes the reticulocytes to be poorly stained.

A. water
B. crystals
C. glucose
D. red cells

14. Howell-jolly bodies appear as deep-purple-staining stuctures and Heinz bodies stain a light _____ and are usually present at the peripheral edge of the red cell.

A. bluish-purple
B. reddish-pink
C. blue-green
D. purplish-blue

INTERMEDIATE OBJECTIVE #2

Perform reticulocyte count.

LEARNING STEPS (Activities)	RESOURCES
1. Observe Resource #1 for a demonstration on reticulocyte count.	1. See instructor.
2. Complete Resource #2 for a practice on performing reticulocyte count.	2. Job Sheet 128-002-002, "Practice Reticulocyte Count", page 13 in this SLG.
3. When mastery of this task has been accomplished, complete Resource #3 for a final performance.	3. Performance Checklist Task #128, "Perform Reticulocyte Count", page in this SLG. See instructor for evaluation.
4. Complete Resource #4 for a written evaluation.	4. Written Criterion Examination, Task #128, "Perform Reticulocyte Count" in LRC. See instructor forevaluation.
5. Proceed to Resource #5 for the next learning guide.	5. See instructor.

JOB SHEET
128-002-002
"Practive Reticulocyte Count"

Directions to the student:

Given the necessary reagents and equipment, practice performing reticulocyte count.

Necessary reagents and equipment:

1. Reticulocyte stain

(Filter prior to use)
a) New methylene blue in solution or
b) Brilliant cresyl blue solution

2. Glass slides.

3. Applicator sticks or microhematocrit tubes.

4. Microscope

Specimen 8

Whole blood (1 ml), using EDTA, heparin or ammonium-potassium oxalate as the anticoagulant. Capillary blood from the finger, toe, or heel may also be used.

Procedure: Page 97 - 98 textbook or refer to Procedures Manual in lab.

PERFORMANCE/PRODUCT CHECKLIST

Program: MEDICAL ASSISTING

Task No: 128

Student's Name: _____ Date Of Attempt: _____

Evaluator's Name: _____ Evaluation Site: _____

Performance Attempt: 1 2 3 4

Terminal Performance Objective:

Given the necessary reagents and equipment, perform a reticulocyte count.

Directions To The Student:

Before attempting this task for mastery, carefully review this checklist. You will be evaluated on the basis of this checklist. When you feel you are ready for evaluation, contact your instructor. You must complete your performance within 10 minutes and must score at least 17 out of 18 points or 90 % for mastery. Critical items are marked with an asterisk (*). These items must be satisfactorily completed.

Directions To The Evaluator:

The student will contact you when ready for the evaluation. The student must complete the performance within 10 minutes and must score 17 out of 18 points or 90 % and all items marked with an asterisk (*) must be satisfactorily completed.

CRITICAL ITEMS	ITEMS TO BE OBSERVED OR CHECKED	RATING YES	RATING NO
*	1. Wash hands		
*	2. Place $\frac{111}{111}$ gtts. of filtered reticulocyte stain in test tube		
*	3. Add $\frac{111}{111}$ gtts. of blood to the test tubes containing the stain		
*	4. Mix the tube contents and allow to stand for a minimum of 15 minutes		
*	5. Mix contents of tube well		
*	6. Use applicator sticks or a microhematocrit tube to place a drop of mixture on each of three slides		
*	7. Make smears		
*	8. Stain with Wright's stain as learned in routine blood smears		
*	9. Allow smears to air dry		
*	10. Place 1st slide on the microscope stage, using low power to find an area in this portion of the smear		
*	11. Change to oil immersion and locate an area of approximately 100 - 200 red cells per field		
*	12. Count reticulocytes in first field		
*	13. Enumerate the reticulocytes in same field with second cell counter		
*	14. Move slide as for a differential count until all reticulocytes in 1000 red cells have been counted		
*	15. Repeat the reticulocyte count with a second technologist - results should be within ± 10% of each other		
*	16. Average the two results		
*	17. Calculate the corrected reticulocyte count		
	18. Clean up working area		
	TOTAL POINTS EARNED =		

POINTS NEEDED FOR MASTERY = 17
TOTAL POINTS POSSIBLE = 18

PROGRAM MEDICAL ASSISTING

CRITERION EXAM

TASK # 128

DIRECTIONS:

THE PURPOSE OF THIS EXAM IS TO DETERMINE WHETHER OR NOT YOU HAVE UNDERSTOOD THE INFORMATION ON PERFORMING RETICULOCYTE COUNT.

Each of the questions or incomplete statements below is followed by several words, phrases, or a series of numbers. Choose the one which best answers the question or completes the statement correctly. Place the letter associated with that choice (A,B,C or D) in the numbered blank space on your ANSWER SHEET. DO NOT WRITE ON THIS TEST!!! To master this exam you must answer 9 out of 10 items correctly, 90%.

EVALUATION SHEET

Written Criterion Examination
TASK #128
"Perform Reticulocyte Count"

Select the BEST answer:

1. The _____ is found in both the bone marrow and peripheral blood.

   A. shite blood cell
   B. reticulocyte
   C. erythrocyte
   D. maturea RBC

2. The bone marrow replaces 1% of the adult red blood cells every day. The normal values for a reticulocyte count, therefore,

   A. 0.15% - 0.5%
   B. 0.5% - 1.0%
   C. 0.5% - 1.5%
   D. 1.5% - .50%

3. The reticulocyte count is expressed as the number of reticulocytes present, per _____ RBC's (in %).

   A. 10
   B. 50
   C. 100
   D. 1000

4. A decreased reticulocyte count is found in conditions in which the bone marrow is not producing red blood cells and

   A. aplastic anemis.
   B. pernicious anemia,
   C. iron deficiency anemia.
   D. hemolytic anemia.

5. _____ cells are indicative of increased red cell production and appear somewhat larger than normal circulating red cells and are polychromatophilic.

   A. Macrocytes
   B. Microcytes
   C. Hematopoietic
   D. "Shift"

6. After the reticulocytes are stained, the number of reticulocytes in 1,000 red cells is divided bt _____ in order to obtain the reticulocyte count in percent.

   A. one
   B. two
   C. five
   D. ten

7. The time allowed for staining fo the reticulocytes is not critical, however, it should never be less than _____minutes.

   A. one
   B. two
   C. five
   D. ten

8. The blood and stain is to be well mixed prior to making smears. Reticulocytes have a _____specific gravity than mature red cells and therefore settle on _____of the red cells in the mixture.

   A. low, top
   B. high, bottom
   C. low, bottom
   D. high, top

9. High concentrations of _____ in the blood causes the reticulocytes in to be poorly stained.

   A. water
   B. crystals
   C. glucose
   D. red cells

10. Howell-jolly bodies appear as deep-purple-staining structures and Heinz bodies stain a light_____and are usually present at the peripheral edge of the red cell.

    A. bluish-purple
    B. reddish-pink
    C. blue-green
    D. purplish-blue

LAKE COUNTY AREA VOCATIONAL CENTER

COMPETENCY-BASED INDIVIDUALIZED VOCATIONAL EDUCATION INSTRUCTION

STUDENT LEARNING GUIDE

Produced By Rosemarie Meyer, RN, CMA Date 3/85

TASK: PERFORM BLEEDING AND CAPILLARY COAGULATION TIMES

* (HIGH TECH)

PURPOSE: THE BLOOD COAGULATION MECHANISM IS COMPLICATED AND INVOLVES MANY FACTORS. KNOWING WHICH FACTOR IS NOT PERFORMING ITS PROPER FUNCTION IS OF CRITICAL IMPORTANCE TO THE PHYSICIAN. THIS KNOWLEDGE IS GAINED THROUGH THE USE OF SEVERAL DIFFERENT LABORATORY TESTS. THIS LEARNING GUIDE WILL ASSIST YOU TO PERFORM BLOOD COAGULATION TESTS.

MEDICAL ASSISTING

emf

Program	Task	Est.Time	Prereq.
07.0904	530	10 H	

LEARNING CONTRACT (optional)

1. STUDENT DATA

NAME _____ SOCIAL SECURITY NUMBER _____

10 H

LENGTH OF CONTRACT (NORMAL TIME IN HOURS)

2. TERMINAL PERFORMANCE OBJECTIVE

Given the necessary tools and equipment, you will perform bleeding and capillary coagulation tests. To master this task you must score 4 (6) out of 5 (7) (90%) on a performance checklist and 14 out of 15 (90%) on a written criterion examination.

2a. INTERMEDIATE OBJECTIVE(s)

1. Describe bleeding and capillary coagulation times.
2. Perform bleeding and capillary coagulation times.

3. AGREEMENT

I, _____ agree to complete the above stated terminal performance requirement within _____ to _____ I further recognize that the conditions of the contract (performance and time agreement) report my ability to perform the requirements of the occupation and record my progress.

Student's Signature

Instructor's Signature
(verifies competency)

INTERMEDIATE OBJECTIVE #1

DESCRIBE BLEEDING AND CAPILLARY COAGULATION TIMES.

LEARNING STEPS (Activities)

1. Read Resource #1 for information on bleeding and coagulation tests.

2. Complete Resource #2 for a review on bleeding and coagulation.

3. Proceed to Resource #3.

RESOURCES

1. Textbook: Basic Techniques for the Medical Laboratory by Linne and Ringsrud, pgs. 271 - 278, 2nd edition in LRC.

2. Job Sheet 530-001-002, "Review Bleeding and Coagulation," pg. 4-6 , in this SLG.

   See instructor for evaluation.

3. IO #2, pg. 7 , in this SLG.

JOB SHEET

530-001-002

"REVIEW BLEEDING AND COAGULATION"

SELECT THE BEST ANSWER.

1. The mechanism of coagulation takes place in three major steps: 1) The formation of thromboplastin, 2) the formation of thrombin, and 3) the formation of:

   A. fibrinogen.
   B. fibrin.
   C. prothrombin.
   D. coagulant.

2. In severe _____ disease a moderate lowering of the plasma fibrinogen level may occur, although rarely to the degree where hemorrhage occurs.

   A. liver
   B. spleen
   C. gallbladder
   D. pancreas

3. _____ is synthesized by the liver through the action of Vitamin K and converted to thrombin by the enzymatic action of thromboplastins.

   A. Fibrinogen
   B. Prothrombin
   C. Calcium
   D. Fibrin

4. _____ thromboplastin is used to designate thromboplastic reagents that are found to clot hemophilic plasma less rapidly than normal plasma whereas _____ thromboplastin is able to produce clotting as rapidly with hemophilic plasma as with normal plasma.

   A. Complete, partial
   B. Partial, complete
   C. Synthesized, manufactured
   D. Converted, produced

5. Clot-accelerating activity of injured tissues has the name factor _____.

   A. II
   B. III
   C. IV
   D. V

6. Factor I, _____, is the soluble precursor of the clot-forming protein, fibrin.

   A. fibrinogen
   B. prothrombin
   C. thromboplastin
   D. calcium

7. A sex-linked hereditary coagulation disorder is _____.

   A. anemia
   B. hemorrhage
   C. congenital
   D. hemophilia

8. The _____ mechanism is the interaction of platelets ⟶ thromboplastin ⟶ prothrombin ⟶ thrombin ⟶ fibrinogen ⟶ fibrin.

   A. bleeding
   B. coagulation
   C. agglutination
   D. hemostatic

9. _____ is the cessation of blood flow from an injured blood vessel.

   A. Hemostasis
   B. Coagulation
   C. Vasoconstriction
   D. Agglutination

10. _____ tests measure the time required for cessation of bleeding after a stab wound to a capillary bed.

    A. Clotting
    B. Prothrombin
    C. Agglutination
    D. Bleeding

11. The two most commonly used bleeding time tests are the _____ and _____.

    A. Duke, Ivy
    B. Quick, cuff
    C. PTT, Pro-time
    D. Lee-White, Mielke

12. The _____ test is the single most useful procedure available for routine screening of coagulation disorders.

    A. Pro-times
    B. Lee-White
    C. PTT
    D. Quick's

13. _____ specimens are always run along with the patient's specimen to ensure accurate results.

    A. Control
    B. Collected
    C. Mixed
    D. Refrigerated

14. The _____ test for Whole Blood Clotting is still used to monitor heparin therapy.

    A. PTT
    B. Lee-White
    C. Pro-time
    D. Titer

15. Excessive probing in venipuncture causes tissue juices to be introduced into the specimen (contamination of tissue thromboplastin). This _____ clotting time.

    A. alters
    B. lengthens
    C. shortens
    D. changes

INTERMEDIATE OBJECTIVE #2

PERFORM BLEEDING AND CAPILLARY COAGULATION TESTS.

LEARNING STEPS (Activities)	RESOURCES
1. Observe Resource #2 for a demonstration on bleeding and coagulation tests.	1. See instructor.
2. Complete Resource #2 for practice on this task.	2. Job Sheet 530-002-001, "Perform Bleeding and Coagulation Tests," pg. 8-9, in this SLG.
3. When you feel you have mastered this task, complete Resource #3.	3. Performance Checklist, pg. 11, in this SLG. See instructor for evaluation.
4. Complete Resource #4 for a written evaluation.	4. Written Criterion Exam, "Perform Bleeding and Capillary Coagulation Tests," in the LRC.
5. Proceed to Resource #5.	5. See instructor for the next learning guide.

JOB SHEET

530-002-001

"PERFORM BLEEDING AND CAPILLARY COAGULATION TIMES"

BLEEDING TIME
(DUKE METHOD)

To do this exercise, you should work in pairs.
Prin.- Bleeding time is the time elapsed between the puncture of the finger and the cessation of bleeding.

PURPOSE:

1. To learn and develop proper techniques of doing bleeding time.

2. To note the time required for a small cut to stop bleeding.

MATERIALS:

1. Piece of filter paper

2. Watch with a second hand

3. Materials for finger puncture:
   a. Gauze pads
   b. Alcohol sponge
   c. Sterile blood lancets

PROCEDURE:

1. Thoroughly cleanse the ball of the patient's middle finger with alcohol sponge and dry it off.

2. Using a sterile blood lancet, make a finger puncture deep enough to insure free flow and quickly record the time.

3. Fold the filter paper in half and at exactly ½ minute after puncturing. lightly touch the filter paper to the blood coming out of the puncture.

4. Repeat the above step every ½ minute until blood ceases to flow

5. Record the time at which blood ceases.

Bleeding time normal - 1 to 3 minutes

JOB SHEET

530-002-001 (Cont'd)

COAGULATION TIME

CAPILLARY METHOD

To do this exercise, it is best to work in pairs.

Prin. - Coagulation time is the time required for blood to clot or coagulate.

PURPOSE:

1. To learn and develop proper technique of doing coagulation time
2. To note the time required for blood to clot or coagulate.

MATERIALS:

1. Watch with a second hand or a stop watch
2. Two plain capillary tubes
3. Materials for finger puncture:
   a. alcohol sponge
   b. gauze
   c. sterile blood lancet

PROCEDURE:

1. Thoroughly cleanse the ball of the middle finger with alcohol sponge and dry it off
2. With a sterile blood lancet, make a quick deep puncture on the ball of the patient's meddle finger.
3. Wipe off the first drop of blood and firmly massage the finger to produce a large rounded drop of blood and record time.
4. Put one end of the capillary tube in the drop of blood and tilt the other end of the capillary tube downward, allowing blood to flow into the capillary tube until it is full.
5. Wipe off the finger with a gauze and firmly massage the finger to get a large rounded drop of blood. Fill up a second capillary tube by repeating the drying, massaging and filling procedure.
6. Pick up the first capillary tube; using both hands break the capillary tube into 2 pieces being careful not to pull the broken ends too far apart.
7. Look for a thread-like span of fibrin between the 2 broken ends.

PERFORMANCE/PRODUCT CHECKLIST

Program: MEDICAL ASSISTING

Task No: 530

Student's Name: _____ Date Of Attempt: _____

Evaluator's Name: _____ Evaluation Site: _____

Performance Attempt: 1 2 3 4

Terminal Performance Objective:

Given the necessary tools and equipment, perform bleeding and capillary coagulation times.

Directions To The Student:

Before attempting this task for mastery, carefully review this checklist. You will be evaluated on the basis of this checklist. When you feel you are ready for evaluation, contact your instructor. You must complete your performance within 10 minutes and must score at least 4 (6) out of 5 (7) points or 90 % for mastery. Critical items are marked with an asterisk (*). These items must be satisfactorily completed.

Directions To The Evaluator:

The student will contact you when ready for the evaluation. The student must complete the performance within 10 minutes and must score 4 (6) out of 5 (7) points or 90 % and all items marked with an asterisk (*) must be satisfactorily completed.

CRITICAL ITEMS	ITEMS TO BE OBSERVED OR CHECKED	RATING YES	RATING NO
	BLEEDING TIME (DUKE METHOD)		
*	1. Thoroughly cleanse the ball of the patient's middle finger with alcohol sponge and dry it off.		
*	2. Using a sterile blood lancet, make a finger puncture deep enough to insure free flow and quickly record the time.		
*	3. Fold the filter paper in half and at exactly 1/2 minute after puncturing, lightly touch the filter paper to the blood coming out of the puncture.		
*	4. Repeat the above step every 1/2 minute until blood ceases to flow.		
*	5. Record the time at which blood ceases.		
	Bleeding time normal - 1 to 3 minutes.		
	COAGULATION TIME (CAPILLARY METHOD)		
*	1. Thoroughly cleanse the ball of the middle finger with alcohol sponge and dry it off.		
*	2. With a sterile blood lancet, make a quick deep puncture on the ball of the patient's middle finger.		
*	3. Wipe off the first drop of blood and firmly massage the finger to produce a large rounded drop of blood and record time.		
*	4. Put one end of the capillary tube in the drop of blood and tilt the other end of the capillary tube downward, allowing blood to flow into the capillary tube until it is full.		
*	5. Wipe off the finger with a gauze and firmly massage the finger to get a large rounded drop of blood. Fill up a second capillary tube by repeating the drying, massaging and filling process.		
*	6. Pick up the first capillary tube; using both hands break the capillary tube into 2 pieces being careful not to pull the broken ends too far apart.		
*	7. Look for a thread-like span of fibrin between the 2 broken ends.		
	TOTAL POINTS EARNED =		

POINTS NEEDED FOR MASTERY = 4 (6)
TOTAL POINTS POSSIBLE = 5 (7)

PROGRAM MEDICAL ASSISTING

CRITERION EXAM

TASK = 530

DIRECTIONS:

THE PURPOSE OF THIS EXAM IS TO DETERMINE WHETHER OR NOT YOU HAVE UNDERSTOOD THE INFORMATION ON PERFORMING BLEEDING AND COAGULATION TESTS.

Each of the questions or incomplete statements below is followed by several words, phrases, or a series of numbers. Choose the one which best answers the question or completes the statement correctly. Place the letter associated with that choice (A,B,C or D) in the numbered blank space on your ANSWER SHEET. DO NOT WRITE ON THIS TEST!!! To master this exam you must answer 14 out of 15 items correctly, 90 %.

EVALUATION SHEET

530-002-004

SELECT THE BEST ANSWER.

1. _____ thromboplastin is used to designate thromboplastic reagents that are found to clot hemophilic plasma less rapidly than normal plasma whereas _____ thromboplastin is able to produce clotting as rapidly with hemophilic plasma as with normal plasma.

   A. Complete, partial
   B. Partial, complete
   C. Synthesized, manufactured
   D. Converted, produced

2. The mechanism of coagulation takes place in three major steps: 1) The formation of thromboplastin, 2) the formation of thrombin, and 3) the formation of:

   A. fibrinogen.
   B. fibrin.
   C. prothrombin.
   D. coagulant.

3. Excessive probing in venipuncture causes tissue juices to be introduced into the specimen (contamination of tissue thromboplastin). This _____ clotting time.

   A. alters
   B. lengthens
   C. shortens
   D. changes

4. The _____ test is the single most useful procedure available for routine screening of coagulation disorders.

   A. Pro-times
   B. Lee-White
   C. PTT
   D. Quick's

5. In severe _____ disease a moderate lowering of the plasma fibrinogen level may occur, although rarely to the degree where hemorrhage occurs.

   A. liver
   B. spleen
   C. gallbladder
   D. pancreas

EVALUATION SHEET

530-002-004 (Cont'd)

6. The _____ mechanism is the interaction of platelets ⟶ thromboplastin ⟶ prothrombin ⟶ thrombin ⟶ fibrinogen ⟶ fibrin.

   A. bleeding
   B. coagulation
   C. agglutination
   D. hemostatic

7. The two most commonly used bleeding time tests are the _____ and _____.

   A. Duke, Ivy
   B. Quick, cuff
   C. PTT, Pro-time
   D. Lee-White, Mielke

8. Factor I, _____, is the soluble precursor of the clot-forming protein, fibrin.

   A. fibrinogen
   B. prothrombin
   C. thromboplastin
   D. calcium

9. _____ is synthesized by the liver through the action of Vitamin K and converted to thrombin by the enzymatic action of thromboplastins.

   A. Fibrinogen
   B. Prothrombin
   C. Calcium
   D. Fibrin

10. A sex-linked hereditary coagulation disorder is _____.

    A. anemia
    B. hemorrhage
    C. congenital
    D. hemophilia

11. Clot-accelerating activity of injured tissues has the name factor _____.

    A. II
    B. III
    C. IV
    D. V

12. _____ is the cessation of blood flow from an injured blood vessel.

A. Hemostasis
B. Coagulation
C. Vasoconstriction
D. Agglutination

13. The _____ test for Whole Blood Clotting is still used to monitor heparin therapy.

A. PTT
B. Lee-White
C. Pro-time
D. Titer

14. _____ tests measure the time required for cessation of bleeding after a stab wound to a capillary bed.

A. Clotting
B. Prothrombin
C. Agglutination
D. Bleeding

15. _____ specimens are always run along with the patient's specimen to ensure accurate results.

A. Control
B. Collected
C. Mixed
D. Refrigerated

LAKE COUNTY AREA VOCATIONAL CENTER

COMPETENCY-BASED INDIVIDUALIZED VOCATIONAL EDUCATION INSTRUCTION

STUDENT LEARNING GUIDE

Produced By Rosemarie Meyer R.N., C.M.A. Date 3/85

TASK: PREPARE SOLUTIONS

PURPOSE:

Preparation of solutions requires strict adherence to specific sets of instructions. Instructions provide the reader with the names of the chemical ingredients, the weights and volumes needed, and the total volume to which the reagent should be diluted. This learning guide will assist the student to prepare solutions.

MEDICAL ASSISTING

Program	Task	Est.Time	Prereq.
07.0904	555	10 hrs.	

edk

LEARNING CONTRACT (optional)

1. STUDENT DATA

NAME _____ SOCIAL SECURITY NUMBER _____

10 hrs.
LENGTH OF CONTRACT (NORMAL TIME IN HOURS)

2. TERMINAL PERFORMANCE OBJECTIVE

Given the necessary tools and equipment, prepare solutions. To master this task, you must score 7 out of 7 (100%) on a performance checklist and score 19 out of 20 (90%) on a written evaluation.

2a. INTERMEDIATE OBJECTIVE(s)

1. Describe solutions.
2. Prepare solutions.

3. AGREEMENT

I, _____ agree to complete the above stated terminal performance requirement within _____ to _____. I further recognize that the conditions of the contract (performance and time agreement) report my ability to perform the requirements of the occupation and record my progress.

Student's Signature _____ Instructor's Signature (verifies competency) _____

Program	Task	Page
07.0904	555	2

INTERMEDIATE OBJECTIVE #1

Describe solutions.

LEARNING STEPS (Activities)

1. Read Resource #1 for information on solutions.
2. Complete Resource #2 for a review on solutions.
3. Proceed to Resource #3.

RESOURCES

1. Information Sheet 555-001-001, "Solutions", pages 4 - 13, in this SLG.
2. Job Sheet 555-001-002, "Review Solutions", pages 14-17 in this SLG. See instructor or activity key for an evaluation.
3. Intermediate Objective #2, page 18 in this SLG.

TABLE 3-8 *Representative conversion factors for customary and metric measurements**

TO CONVERT FROM	TO	MULTIPLY BY
Acres	Square feet	43,560
Acres	Square kilometers	0.004
Angstrom units	Centimeters	1×10^{-8}
Angstrom units	Nanometers	0.1
Centimeters	Feet	0.0328
Centimeters	Inches	0.3937
Feet	Inches	12
Feet	Meters	0.3048
Gallons (U.S. liquid)	Liters	3.7854
Gallons (U.S. liquid)	Ounces	128
Grams	Kilograms	0.001
Grams	Pounds	0.002
Inches	Meters	0.254
Inches	Yards	0.0278
Liters	Ounces	33.815
Liters	Pints	2.113
Meters	Feet	3.2808
Meters	Kilometers	0.001
Micrograms	Grams	1×10^{-6}
Micrometers	Angstrom units	10,000
Micrometers	Nanometers	1000
Pounds	Kilograms	0.45
Pounds	Grams	453.6
Square meters	Square feet	10.8
Square meters	Square yards	1.2
Yards	Meters	0.9
Yards	Centimeters	91.4

*Approximate.

appropriate factor to produce the unknown value in the needed unit. For example, suppose we wanted to determine the number of centimeters in 5 inches. The conversion factor is 2.54. Multiply 5 (inches) × 2.54 to produce 12.7 centimeters.

PREPARATION OF SOLUTIONS

Preparation of solutions requires strict adherence to specific sets of instructions. Instructions provide the reader with the names of the chemical ingredients, the weights or volumes needed, and the total volume to which the reagent should be diluted. Throughout this book we shall refer to the chemical ingredients as *reagents*. As you progress through *Medical Laboratory Skills*, reagent preparation will form an essential part of your training.

Read and follow the instructions for preparing reagents carefully. The quantities of chemicals listed in the order in which some chemicals are added, and the solvent used for dissolving or diluting are important considerations. Preparation of most solutions requires the use of volumetric glassware. This usually includes volumetric pipets and volumetric flasks or cylinders.

Many of the chemicals used in the laboratory are solids. These ingredients must be weighed in quantities of grams (g) or milligrams (mg). Liquids are usually measured by volume, in milliliters (ml), deciliters (dl), or liters (l). Only high-grade chemicals should be used as reagents and they should be obtained from a reputable supplier.

The Nature of Solutions

Solutions used as reagents in most clinical analyses consist of *solvents* and *solutes*. Solvents are substances, usually liquids, that dissolve a solid. Solutes are solids dissolved by solvents. Distilled or deionized water is most often used as a solvent. Tap water is *never* used in preparing reagents because of the impurities it may contain. Alcohols, acids, and combinations of liquids are sometimes used as solvents.

Some solutes dissolve as complete molecules and remain in that state. Other solutes, such as salts, break up into charged particles. These particles are called *ions*. When sodium chloride (NaCl) is dissolved in water it dissociates into charged particles. Sodium (Na^+) and chloride (Cl^-) ions are formed.

Solutes that ionize in solution are called *electrolytes*. Solutions of electrolytes can conduct electricity. The behavior of these solutions is different from solutions whose solutes remain in the molecular state.

Some of the solutions prepared for laboratory use are easily made by dissolving one or more solids in a liquid. Occasionally one or more liquids must be diluted with another liquid. More complicated solutions require heating, adjustment of pH, and additional steps such as refluxing or distillation.

Saturated solutions contain as much solute as can be held in solution. When a solution is saturated, excess amounts of solute will settle out of solution and remain on the bottom of the vessel.

Colloidal solutions are solutions in which the solute particles are atomic or molecular in size, but light enough to remain in suspension. Colloids cannot be filtered. Some substances are present in biological fluids

Taken from: Medical Laboratory Skills, by Wittman & Thomas

as colloidal suspensions. Reagents sometimes used in the laboratory are colloidal solutions.

Types of Solutions

The solutions used in most laboratory procedures do not require the writing of chemical equations for their preparation. The ability to perform mathematical calculations and some understanding of valence is necessary.

Solution concentrations are expressions of the amounts of substances in solution. The expression of concentration is always in relation to the volumes or masses of other parts of the solution. One method of expressing solution concentration is to indicate the concentration in amounts that react chemically. *Molar* solutions and *normal* solutions are expressions of concentration in chemical terms.

Molar Solutions

Molarity is the number of gram molecular weights of a compound per liter of solution. This concentration may also be expressed as the number of *moles* per liter of solution. The molecular weight expressed in grams is equal to one mole of the compound.

The molecular weight is computed by first calculating the atomic weights of all the elements in the compound. This information can be obtained easily by looking at a table of atomic weights in a chemistry text. The molecular weight is determined by adding the weights of all the atoms contained in a compound.

The correct formula of the compound must be known. This information is printed on reagent bottles or it may be found in a handbook of chemistry. The number of moles can be determined by dividing the number of grams of the compound present by the molecular weight in grams.

EXAMPLES

1. The formula for hydrochloric acid is HCl. This indicates that hydrochloric acid contains 1 atom of hydrogen and 1 atom of chlorine. The gram molecular weight is equal to the sum of the atomic weights.

$$\begin{aligned} H &= 1 \\ Cl &= 35.5 \\ \text{Gram molecular weight} &= 36.5 \text{ g} \end{aligned}$$

One mole of hydrochloric acid weighs 36.5 g. A 1 molar (M) solution contains 36.5 g of HCl per liter.

2. The formula for sodium carbonate is Na_2CO_3. This indicates that sodium carbonate contains 2 atoms of sodium, 1 atom of carbon, and 3 atoms of oxygen. The gram molecular weight is determined in a similar way to that of HCl in example 1.

$$\begin{aligned} 2\ Na &= 23 \times 2 = 46 \\ 1\ C &= 12 \times 1 = 12 \\ 3\ O &= 16 \times 3 = 48 \\ \text{Gram molecular weight} &= 106 \text{ g} \end{aligned}$$

One mole of sodium carbonate weighs 106 g. A 1M solution contains 106 g of Na_2CO_3/liter.

For practical purposes it is not always necessary to prepare solutions in liter quantities. The student should realize that it is sometimes necessary to scale down the quantities used or to use multiple quantities for greater volumes.

The following formulas may be used to calculate molarity:

$$\text{Molarity} = \frac{\text{number of grams of solute}}{\text{molecular weight in grams}} \times \frac{1}{\text{liters of solution}}$$

Substitution and rearrangement gives us

$$\text{Molarity} = \frac{\text{number of moles of solute}}{\text{liters of solution}}$$

Normal Solutions

It is often necessary to make a comparison of solution strengths. When this is desirable, the solution concentrations should be expressed in terms of *normality*. Normality requires an understanding of *equivalents* and *equivalent weights*.

Normality describes the number of equivalent weights per liter of solution. Normal solutions are also called *equivalent solutions*. An equivalent weight is the weight in grams of a substance that will replace one gram atomic weight (atomic weight in grams) of hydrogen ions (H^+).

PROCEDURE Fill the buret above the zero mark, and adjust the meniscus to exactly zero by manipulating the stopcock. The tip of the buret must be completely filled and free of trapped air bubbles or plugs. For the titration of samples the following procedure should be used:

1. Using a volumetric pipet, carefully pipet the solution to be titrated into an Erlenmeyer flask.
2. Add the required amount of indicator.
3. Add the titrant from the buret to the solution in the flask by manipulating the outflow of titrant with the stopcock.

The procedure for manipulating the buret stopcock is somewhat awkward at first. A right-handed person must use the left hand for this operation. The thumb and index finger are usually used. The solution in the flask is mixed by swirling with the right hand. The meniscus must be adjusted to zero, and this reading should be recorded before starting the titration.

4. Add the titrant in rapid drops at first. As the end point is approached, add only portions of a drop. This is called *splitting drops*.
5. Titrate to the appearance of a faint, but lasting color. This procedure should be followed unless specific instructions indicate otherwise.
6. Record the buret reading. (See Fig. 3-2.)

It is sometimes advisable to waste one sample so the approximate end point may be determined. Two samples should be titrated and the average of the two should be used to calculate the concentration of the sample. Upon completion of the titration, the buret should be rinsed well with tap water and then with distilled or deionized water.

FIGURE 3-2. Technique for using a buret for titration. Manipulate the stopcock with one hand while gently mixing the solution contained within the flask with the other hand.

QUALITY CONTROL

Clinical laboratory tests must be precise, accurate, and reliable to be useful in diagnosing disease. By precise, we mean each test result must be exact, clearly stated, and well defined. To be accurate, each test result must be free from error. Results are reliable if they can be repeated with the same degree of precision and accuracy time after time.

All test results are variable to some degree. The degree of acceptable variation from the normal value is based mainly on statistics. When much information is assembled about a particular physiological pattern, it is possible to determine a suitable range of normal and abnormal values. One aspect of quality control is to make sure that the source of test result variability is due to pathology and not a problem in the design, application, or performance of the procedure.

Assessment of accuracy is another major concern of quality control. We have seen that variability of physiological systems provides no absolute, correct values for measurements made in the laboratory. Accuracy can be determined by comparing the results obtained on the same sample by another equally competent and experienced worker.

Accuracy can also be determined by comparing the value of a standard and previously known sample against results obtained by the worker when using

two liquids. The concentration is expressed as milliliters per unit volume of solution. Volume per unit volume is denoted as milliliters per milliliter (ml/ml) or milliliters per liter (ml/l).

EXAMPLE Prepare 500 ml of acetic acid with a concentration of 0.25 ml/ml. A simple proportion may be used to solve this problem, as follows:

$$\frac{0.25 \text{ ml}}{1 \text{ ml}} = \frac{x \text{ ml}}{500 \text{ ml}}$$

$$x = 125 \text{ ml}$$

Thus 125 ml of acetic acid is measured and diluted to a final volume of 500 ml.

Weight/weight is an expression of concentration that is seldom used. Whenever solid chemicals are mixed or diluted with other solids this notation is indicated. Weight per unit weight is expressed as milligrams per milligram (mg/mg) or grams per gram (g/g).

Procedures and the Preparation of Reagents

Commercially prepared, preweighed packages of solutions are finding widespread use in the laboratory. These solutions are highly recommended for laboratories that use automated procedures. Consumption of reagents in these laboratories is far greater than in those that use manual procedures. The time saved in reagent preparation probably offsets the cost. Yet students must realize that even with the use of commercially prepared reagent packets, some reagents will still have to be prepared.

Only chemicals of the highest degree of purity should be used in the clinical laboratory. Reagents designated as pure contain only the compound described with no impurities used as fillers. *Analytical reagent grade (AR)* compounds are of the highest degree of purity. Those designated as *American Chemical Society (ACS)* meet the standards of the American Chemical Society for analytical grade reagents. *Chemically pure (cp)* grade reagents have purity that is generally suitable for clinical laboratory purposes. Look for one of these designations to be sure of using suitable reagents.

GENERAL PROCEDURES The basic characteristics and hazards of reagents are always printed on container labels. Proper and safe handling and storage practices should be followed for chemicals used in the laboratory. The following includes some fundamental rules:

1. Replace the covers of all reagent bottles promptly and securely.
2. Store dry chemicals in a cool, dry place.
3. Store flammable materials in a cool area removed from open flames or sparks.
4. Handle volatile substances and substances that produce irritating fumes under a fume hood.
5. Dry substances that absorb moisture in a drying oven or desiccator prior to weighing. Failure to remove this moisture will result in an incorrect weight.

Quantitative Transfer

Precise weighings and measurements that are practiced in the clinical laboratory require the use of the technique called *quantitative transfer*. This technique ensures that the entire amount of substance that is weighed or measured will actually be incorporated into the substance being prepared.

The technique of quantitative transfer is used when a solid or a liquid is transferred from one container to another and is especially important when dilution to a specified volume must be made.

Quantitative transfer should be performed in a section of the laboratory that is free from pedestrian traffic and air currents. All glassware and materials should be assembled. A wash bottle should be filled with the appropriate diluent.

Chemicals are usually weighed into beakers or onto weighing paper. The object of performing a quantitative transfer is to transfer the entire quantity from the weighing vessel or paper to the flask for final dissolution and dilution.

Whenever possible the chemical should be mixed and dissolved in the weighing vessel. This step will facilitate the transfer to the volumetric flask. When a glass stirring rod is used it should remain with the weighing vessel until the transfer is complete.

The volumetric flask should be fitted with a clean, dry funnel. The solid or dissolved material must be

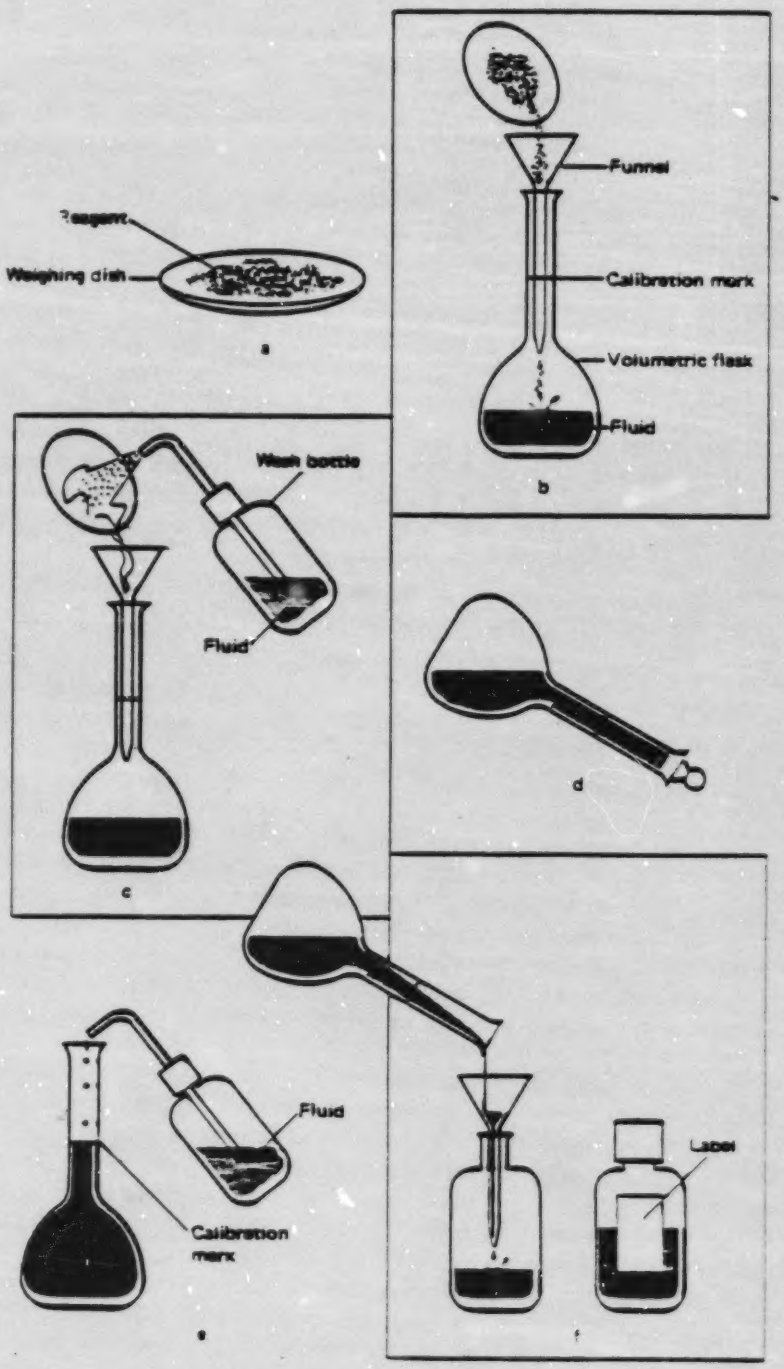


FIGURE 3-1. Quantitative transfer technique. (*a*) Weigh reagent. (*b*) Empty the reagent using a funnel into a volumetric flask containing some liquid. (*c*) Use a wash bottle several times to remove all reagent from the dish. (*d*) Invert or shake to mix. (Remember to place the cap on the flask before mixing.) (*e*) Fill the flask to the calibration mark using more liquid and mix again. (*f*) Pour the reagent solution into the stock bottle and label.

Program	Task	Page
07.0904	555	8

carefully transferred, *without any loss*, to the funnel in the flask. With the lip of the beaker held in place at the funnel, carefully rinse the inside of the beaker with small portions of diluent using a wash bottle.

Repeat this procedure approximately five times, or until all visible evidence of the solid is gone. Add all rinsings to the volumetric flask. Rinse the funnel with the diluent and remove it from the flask. Add a sufficient amount of diluent to the flask to bring about dissolution of the solid. Be sure that all of the solid is dissolved. Allow for cooling to room temperature if heat is evolved or applied during the process.

Add diluent to within one inch of the calibration mark. Carefully add additional diluent to adjust the level of liquid. The bottom of the meniscus must be *exactly* even with the calibration mark. Stopper the flask and invert it several times to mix the contents. (See Fig. 3-1.)

TITRATION

Clinical laboratory methods frequently require that the concentration of substances be determined using volumetric techniques. Such procedures are used to calculate the volume of a reagent solution needed to react with a specific volume of a sample. The sample may be a biological fluid or an extract of a biological fluid. Sometimes the sample is simply another reagent. The technique that may be used for this process is *titration*.

Concept of Titration

Titration requires the addition of a solution of known concentration, called a *standard*, to an accurately measured volume of sample. The reagent or standard is added dropwise, usually from a buret, until a sudden change is noticed in the appearance of the solutions being mixed.

The change may be indicated by the appearance of a precipitate. If a chemical indicator is used a color change will occur. A precise change in pH is sometimes required that can be monitored with a pH meter. When a noticeable change occurs, the *end point* of the reaction has been reached and the desired concentration determined. End points must be approached carefully to avoid overtitrating.

TABLE 3-9 *Chemical indicators used in the clinical laboratory for titration*

INDICATOR	pH RANGE	COLOR CHANGE	
		ACID	ALKALINE
Töpfer's reagent	2.8–4.0	Red	Yellow
Congo red	3.0–5.0	Blue	Red
Methyl orange	3.1–4.4	Red	Yellow
Phenol red	6.8–8.4	Yellow	Red.
Phenolphthalein	8.3–10.0	Colorless	Red

Concentrations of standard solutions are usually expressed in normality, and the concentration of the sample solution may then be directly compared and calculated. Titration is frequently used in the preparation of various reagents and in some clinical procedures described in other sections of this book.

Selection of Indicators

The end point of a titration reaction is often determined by using a chemical *indicator*. Indicators are usually weak acids or weak bases that ionize to form a color different from the undissociated (not ionized) form. Chemical indicators respond to changes in hydrogen ion concentration and therefore detect changes in solution pH.

The choice of which indicator to use for a specific procedure will require a thorough knowledge and understanding of the pH range present at the end point of the reaction. The methodologies supplied for laboratory procedures usually list the indicator to be used and the end point to be expected (See Table 3-9.)

Procedures

A clean, calibrated buret or similar device must be used. The buret and its capillary tip must be free from cracks and chips. During the titration procedure a buret clamp and stand are used to secure the buret. The buret stopcock must turn easily and smoothly.

Prior to using the buret it must be rinsed well with the solution that it will contain. This solution is called the *titrant*. Rinsing can be done easily by filling the buret and allowing the titrant to drain. This process should be repeated several times. The rinse solution should always be discarded.

The equivalent weight of a compound is determined by first computing the gram molecular weight. The gram molecular weight must then be divided by the valence of the positive ion(s) in the compound. Other useful terms that describe normality include milliequivalents per liter (meq/l) or milliequivalents per milliliter (meq/ml).

EXAMPLES

1. The formula for potassium chloride is KCl. This compound ionizes in solution to form 1 K^+ (potassium ion) and 1 Cl^- (chloride ion). The positive valence is +1. The equivalent weight for this compound is equal to the molecular weight, as follows:

$$\text{Equivalent weight} = \frac{\text{molecular weight}}{+1}$$

2. The formula for sulfuric acid is H_2SO_4. This compound ionizes in solution to form $2H^+$ and 1 complex sulfate ion $(SO_4)^=$.

The total positive charge on this molecule is 2. The equivalent weight for sulfuric acid is equal to the molecular weight divided by 2.

The following formulas may be used to calculate normality:

$$\text{Normality} = \frac{\text{number of grams of solute}}{\text{gram molecular weight/ total positive charge}} \times \frac{1}{\text{liters of solution}}$$

Substitution and rearrangement gives us,

$$\text{Normality} = \frac{\text{equivalents of solute}}{\text{liters of solution}}$$

Percent Solutions (%)

Percent solutions are an expression of concentration as parts per hundred. Solid or liquid chemicals may be used for the preparation of percent solutions. When the solute is a solid, the percent solution denotes grams of solute per 100 ml of solution (g/100 ml). When a liquid chemical is used, the percent solution denotes milliliters per 100 ml of solution (ml/100 ml).

Some solids are weighed in milligram quantities and diluted to 100 ml. The concentration is expressed as milligrams percent (mg%). This notation is frequently used to express the concentration of standard solutions. The more current notation, milligrams per deciliter (mg/dl), is replacing milligrams percent.

EXAMPLES

1. 50 ml of hydrochloric acid (HCl) is diluted to 100 ml in a volumetric flask. What is the concentration in percent?

$$\frac{50 \text{ ml}}{100 \text{ ml}} \times 100 = 50\%$$

2. 40 g of sodium chloride (NaCl) is diluted to 250 ml. What is the concentration in percent? A simple proportion may be used to solve this problem, as follows:

$$\frac{40 \text{ gm}}{250 \text{ ml}} = \frac{x \text{ gm}}{100 \text{ ml}}$$
$$250x = 4000$$
$$x = 16\%$$

Weight/Volume Solutions

These solutions are an expression of concentration as the amount of solute per unit volume. This notation is used when a solid is dissolved and diluted in a liquid. Weight per unit volume is expressed as grams per liter (g/l) or milligrams per milliliter (mg/ml).

EXAMPLE

Prepare 200 ml of a solution containing 25 mg/ml. This problem may be solved by using a simple proportion:

$$\frac{25 \text{ mg}}{1 \text{ ml}} = \frac{x \text{ mg}}{200 \text{ ml}}$$
$$x = 5000 \text{ mg or } 5 \text{ g}$$

Thus 5 g of the solute is weighed and diluted to 200 ml in a volumetric flask.

Volume/Volume

Another type of solution, volume/volume, is an expression of concentration used for the dilution of

that standard in the clinical procedure. We may assume that the values of all unknown samples are free from error if results from testing the standard conform to its expected value.

There is a direct relationship between the reliability of laboratory test results and the technical competence and experience of the staff. Many sources of error are traceable to worker carelessness, either sloppy procedure or incorrect use of equipment, supplies, and reagents. Other sources of error include defective equipment and incorrect patient identification and reporting.

Worker Carelessness

A major source of error in the clinical laboratory is worker carelessness, which can develop in even the most highly trained individuals.

Performance of routine procedures over a long period of time can lead to monotony and overconfidence. When we become overconfident, we tend to rely more upon memory than upon printed procedures. Distraction and boredom frequently cause careless habits to develop. All laboratory workers must avoid these pitfalls and attempt to maintain work habits and attitudes that prevent these weaknesses from developing.

Deviations from proven procedures and unorthodox innovations are probably the most common examples of worker carelessness. Laboratory data must be recorded as it is collected. Do not rely on memory. Perform mathematical calculations carefully, avoid time pressures, and always double check your work.

Defective Equipment and Supplies

All laboratory workers have the responsibility of using equipment and supplies that are free of defects. Frequent inspection of equipment and supplies should be made. Newly received materials should be inspected for defects in workmanship and design. It is not uncommon in this age of mass production to receive equipment that is defective in one way or another. Defects can also develop during shipment and handling.

Pipets and volumetric glassware should be inspected and checked prior to their use. Pipets with broken or chipped tips must be discarded. Check bottled reagents for expiration date and breakage.

Electronic equipment should be tested and calibrated prior to actual use. Most manufacturers provide detailed instructions for the calibration of their instruments. Replace broken or damaged parts and keep a supply of spare parts on hand.

Use of Uncalibrated Instruments or Glassware

All glassware used for diluting or preparing reagents and measuring samples must be calibrated. Analytical results depend upon exact quantities or *aliquots*. An aliquot is a carefully measured sample that is considered representative of the entire specimen. Use of uncalibrated glassware or equipment in analytical work will lead to errors and yield unreliable results.

Incorrect Use, Formulation, or Contamination of Reagents

Laboratory tests require specific materials and reagents. The reagents used must be prepared according to specific instructions and techniques. Some reagents may be used for more than one test. Others are highly specialized and their use is unique for detection of certain substances.

Careful attention must be given to the ingredients that go into the formulation of reagents and to the instructions for their preparation. Each constituent has been selected, and the quantity necessary for reaction has been determined on the basis of scientific principles and research. Accuracy will be affected by improperly prepared reagents. Chemical reactions may not occur or they may not proceed to completion.

Reagents of the correct concentration must be used, and these reagents must be added to a reaction mixture in a specific order. Desired reactions may also depend upon the mixture's being at a specific pH.

Reagents used in clinical tests must always be free of contamination. Check for bacterial contamination in liquid reagents. Turbidity (cloudiness) is a sign of bacterial growth. Dry reagents must be inspected for contamination by moisture and deterioration caused by heat. Reagents must be pure and uncontaminated by other laboratory substances. Always use clean containers to prepare and store reagents, and provide complete labels for each of these containers.

Incorrect Patient Identification and Reporting

One of the greatest responsibilities facing laboratory staff members is proper identification of patients, their specimens, and their laboratory reports. Misidentification of patients and their results may cause the death or discomfort of a patient. Mismatched blood transfusions may be given accidentally, treatments may be withheld, or unnecessary treatments may be administered.

Identification systems used in the laboratory should be clearly understood by all workers. Frequently used systems may vary slightly from one institution to another. Usually an identifying number, such as the patient's social security number, is assigned to the individual. Other information, such as date of birth, sex, and address may be encoded. Whatever the number, it is unique and remains with the patient for all visits to the institution.

Hospital patients are usually assigned an identification bracelet and a bed card. The laboratory ordinarily follows directions written on a laboratory request slip. All information on this slip must be verified prior to collection of the specimen. If errors are discovered, the nurse in charge must be contacted and asked for verification of the information. Unidentified or unlabeled specimens received by the laboratory must be returned.

All equipment and supplies should be identified and labeled at the patient's bedside. Identification of infants, children, and foreign-speaking patients must be carefully determined. When in doubt about correct identification, ask your superior. Never be afraid to question positive identification of a sample.

Inherent Limitations of Clinical Tests

Every test performed in the clinical laboratory has limitations that must be recognized. These limitations may be based on factors related to the tests themselves, or to random errors on the part of the worker, the materials, or the equipment, which cannot easily be controlled. Laboratory results are, at best, estimations.

One major limiting factor is the *specificity* of the procedure. We may ask questions: Is the procedure measuring all of the desired substance present in the sample? Is it measuring other unrelated compounds that are present? How much do other substances interfere with the measurement of the desired substance?

The size of the sample actually used in comparison with the amount available may be a source of error. We usually collect a sample of several milliliters of blood, for example, yet in some instances only a few cubic millimeters are analyzed. Is this very small sample typical of all the blood in the body?

The use of so-called normal values, which provide us with a basis for comparison, is a major concern to some clinicians. Some advocate the establishment of normal values by each laboratory rather than relying on a set of normal values used by all laboratories in the country. Normal values depend upon the group that is sampled. Geographical location, patterns of living, age group, and the number of people sampled are all factors that influence establishment of normal values. Locally obtained normal values may more accurately reflect the results to be expected from other members of that population.

Control Methods

The physician depends on the results of clinical laboratory determinations for the diagnosis and treatment of disease. Faced with this responsibility, the medical laboratory utilizes several procedures to ensure the precision, accuracy, and reliability of results.

One of the simplest ways of checking reliability is the use of *duplicate analyses*. Limits can be established for allowable variation. Values that fall within these allowable limits are acceptable. Values that exceed the acceptable limits are rejected. These limits are calculated by statistical methods.

Another means of ensuring accuracy of results is through the use of *control solutions*. It is customary procedure to run *low*, *normal*, and *high* controls on a daily basis. This means that standard solutions are used that have been analyzed previously and will give a range of normal results. The controls are routinely included and analyzed with the patient samples. Three types of controls are used: reagent blanks, standard solutions, and reference materials.

Reagent blanks are usually run as a means of correcting for color or characteristics that might occur as natural phenomena. This may be caused by incl-

vidual reagents or an interaction between the reagents used in the test.

Standard solutions provide the basis for comparison of test samples with the pure substance under investigation. Standard solutions are solutions of known concentrations that enable us to make our comparison.

Reference materials are usually human sera or plasma that have been assayed by an independent laboratory or analyst. These materials are often used as a control.

The primary purpose of using a control is to check reagents, standards, technique, and equipment. Control solutions are subjected to the same conditions and treated with the same reagents as the test samples. The reliability of results can be judged if the "correct" value of the control is known. Controls are always run with each batch of tests.

Commercially prepared controls are available. These materials are usually dehydrated samples of pooled human sera or plasma. The pools are assayed by the manufacturer, and the values are provided for a variety of constituents.

Since the samples are taken from human pools, they contain a variety of constituents. Each vial can be used for more than one determination. The ranges of acceptable values are supplied by the manufacturer. Results for control samples must be within the limits of acceptable value before any test samples can be reported.

Many laboratories prefer to prepare their own control solutions. This can easily be done by pooling all leftover normal serum or plasma samples. Several liters are usually collected. Individual samples must be preserved by freezing. The normal average value is determined by running approximately 25 individual tests on a daily basis.

Statistics are used to determine the expected range of values for the control. A control sample is then included with each batch of determinations.

Another method of using controls is to prepare a visual chart known as a *quality control chart*. Acceptable limits are indicated on the chart and it permits immediate determination, by visual means, as to whether or not a value is acceptable. Trends leading toward incorrect values can be readily observed and possibly forestalled. The use of control materials is not limited to the chemistry laboratory. These items are available for urinalysis, hematology, bacteriology, serology, and blood banking.

Standard Solutions

An essential part of all laboratory tests are *standard solutions*. They provide a basis for comparison or a frame of reference. Standards are prepared from chemically pure substances. They must be accurately weighed and diluted to an exact volume. When handled in this way the final concentration is exact. Volumetric glassware is used and weighing is performed on an analytical balance.

The standards used in chemical analysis may be obtained from the National Bureau of Standards. Certificates listing the purity of the compounds are usually supplied with these standards. A standard may be prepared as an *aqueous solution*, an *intermediate product*, or some artificial substance such as a dye. Standards are often processed in the same way and with the same reagents as the patient samples or controls. However they are introduced into the test system, their purpose is one of comparison of test samples with that of the standard.

Internal standards are prepared by adding a known amount of pure substance to one of the samples under analysis. This is sometimes done to introduce factors present in samples that are not present in aqueous standard solutions.

Most standards are prepared in concentrated form called *stock standards*. Dilutions of the stock standard, using quantitative technique, are used during analysis. The diluted form of the stock standard is called a *working standard*. Quantitative technique must be used in handling all standard materials, since the results of the analysis depends on the standard concentration.

JOB SHEET

555-001-002

"REVIEW SOLUTIONS"

Select the BEST answer.

1. Preparation of solutions requires the use of _____ glassware.

   A. graduated
   B. volumetric
   C. serological
   D. measured

2. _____ are substances, usually liquids, that dissolve a solid.

   A. Solutes
   B. Solvents
   C. Solutions
   D, Molars

3. Solutes, such as salts, break into changed particles called _____.

   A. electrolytes.
   B. ions.
   C. molecules.
   D. atoms.

4. _____ is the number of gram molecular weights of a compound per liter of solution.

   A. Solutions
   B. Suspensions
   C. Scales
   D. Molarity

5. This formula may be used to calculate molarity:

$$\text{Molarity} = \frac{\text{number of grams of solute}}{\text{molecular weight in grams}} \times \frac{1}{\text{liters of solution}}$$

   A. liters of solution
   B. gram molecular weight.
   C. liter quantities.
   D. equivalent weights.

6. The following formula may be used to calculate normality:

$$\text{Normality} = \frac{\text{gram molecular weight/total positive change} \times 1}{\text{liters of solution}}$$

A. equivalents of solute.
B. number of grams of solute
C. number of moles of solute
D. molecular weight in grams

7. The chemical with the highest degree of purity used in the clinical laboratory is

A. chemically pure.
B. analytical reagent grade.
C. saturated solution.
D. chemical reagent grade.

8. Some fundamental rules to follow when handling and storing chemicals include replacing covers, storing flammables in a cool area, handling volatile substances under a fume hood, and storing dry chemicals in a _____ place.

A. cool, dry
B. wet, moist
C. cool, moist
D. flat, cool

9. This technique assures precise _____ weighings and measurements that are practiced in the clinical laboratory.

A. qualitative analysis
B. quantitative transfer
C. pipetting technique
D. qualitative transfer

10. The technique used to calculate the volume of a reagent solution needed to react with a specific volume of a sample is

A. quantitative transfer.
B. quality control.
C. standard solutions.
D. titration.

11. Titration requires the addition of a solution of known concentration called a _____, to an accurately measured volume of sample.

A. indicator
B. titrant
C. solvent
D. standard

12. The end point of a titration reaction is often determined by using a chemical _____, weak acids or weak bases.

A. base
B. indicator
C. reagent
D. standard

13. For the titration procedure a clean, calibrated _____or similar device must be used.

A. tube
B. flask
C. pipette
D. buret

14. Clinical laboratory _____must be precise, accurate and reliabe to be useful in diagnosing disease.

A. procedures
B. tests
C. methods
D. preparations

15. The major source of error in the clinical laboratory is worker _____, which can develop in even the most highly trained individuals.

A. overconfidence
B. performance
C. calculations
D. carelessness

16. Equipment and supplies used by all laboratory workers are to be free of _____.

A. defects.
B. inspection.
C. breakage.
D. overuse.

17. All glassware used for diluting or preparing reagents and measuring samples must be

A. pre-examined.
B. calibrated.
C. non-breakable.
D. stored.

18. To insure liquid reagents used in clinical tests be free of bacterial contamination, check for _____, a sign of bacterial growth.

A. odor
B. moisture
C. deterioration
D. turbidity

19. One of the greatest responsibilities facing laboratory staff members is proper _____of patients, their specimens and their laboratory reports.

A. identification
B. recognition
C. clarification
D. recording

20. Several procedures ensuring precision, accuracy and reliability of results of clinical laboratory determinations are duplicate analysis, reagent blanks, control solutions, reference materials, and

A. stock standards.
B. quantitative transfers.
C. standard solutions.
D. prepared samples.

INTERMEDIATE OBJECTIVE #2

Prepare solutions

LEARNING STEPS (Activities)

1. Observe Resource #1 for demonstration on titration of samples.
2. Practice preparing solutions by using Resource #2 as a guide.
3. For mastery of this task, complete Resource #3.
4. Complete Resource #4 for a written evaluation.
5. Proceed to Resource #5.

RESOURCES

1. See instructor.
2. Job Sheet 555-002-002, "Practice Titration", page 19 in this learning guide.
3. Performance Checklist, pages 20-21 in this SLG.
4. Written Criterion Exam, Task #555, "Prepare Solutions," in the LRC. See instructor for evaluation.
5. See instructor for next learning guide.

JOB SHEET

555-002-002
"PRACTICE TITRATION"

Directions to the student:

With the necessary equipment and supplies practice titration.

Necessary equipment and supplies:

Volumetric pipet
Erlenmeyer flask
Buret with stopcock
Titrant
Distilled water

Procedure:

1. Using a volumetric pipet, carefully pipet the solution to be titrated into an Erlenmeyer flask.
2. Add the required amount of indicator.
3. Add the titrant from the buret to the solution in the flask by manipulating the outflow of titrant with the stopcock.
   The procedure for manipulating the buret stopcock is somewaht awkward at first. A right handed person may use the left hand for this operation. The thumb and index finger are usually used. The solution in the flask is mixed by swirling with the right hand. The meniscus must be adjusted to zero, and this reading should be recorded before starting the titration.
4. Add the titrant in rapid drops at first. As the end point is approached, add only prtions of a drop. This is called splitting drops.
5. Titrate to the appearance of a faint, but lasting color. This procedure should be followed unless specific instructions indicate otherwise.
6. Record the buret reading (See Fig. 3-2).

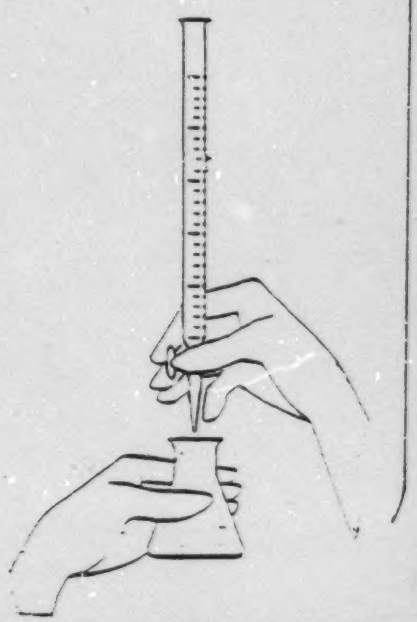


FIGURE 3-2. Technique for using a buret for titration. Manipulate the stopcock with one hand while constantly mixing the solution contained within the flask with the other hand.

Program	Task	Page
07.0904	555	19

PERFORMANCE/PRODUCT CHECKLIST

Program: MEDICAL ASSISTING

Task No: 555

Student's Name: _____ Date Of Attempt: _____

Evaluator's Name: _____ Evaluation Site: _____

Performance Attempt: 1 2 3 4

Terminal Performance Objective:

Given the necessary equipment and supplies, prepare solutions.

Directions To The Student:

Before attempting this task for mastery, carefully review this checklist. You will be evaluated on the basis of this checklist. When you feel you are ready for evaluation, contact your instructor. You must complete your performance within _____ minutes and must score at least _____ out of _____ points or _____ % for mastery. Critical items are marked with an asterisk (*). These items must be satisfactorily completed.

Directions To The Evaluator:

The student will contact you when ready for the evaluation. The student must complete the performance within _____ minutes and must score _____ out of _____ points or _____ % and all items marked with an asterisk (*) must be satisfactorily completed.

CRITICAL ITEMS	ITEMS TO BE OBSERVED OR CHECKED	RATING YES	RATING NO
*	1. Pipet with a volumetric pipet into an Erlenmeyer flask.		
*	2. Add the required amount of indicator.		
*	3. Add the titrant from the buret to the solution in the flask by manipulating the buret stopcock.		
*	4. Add the titrant in rapid drops at first.		
*	5. As end point is approached, add only prtions of a drop.		
*	6. Titrate to a fast, but lasting color.		
*	7. Record the buret reading.		

TOTAL POINTS EARNED =

POINTS NEEDED FOR MASTERY = 7
TOTAL POINTS POSSIBLE = 7

PROGRAM MEDICAL ASSISTING

CRITERION EXAM

TASK = 555

DIRECTIONS:

THE PURPOSE OF THIS EXAM IS TO DETERMINE WHETHER OR NOT YOU HAVE UNDERSTOOD THE INFORMATION ON **PREPARING SOLUTIONS.**

Each of the questions or incomplete statements below is followed by several words, phrases, or a series of numbers. Choose the one which best answers the question or completes the statement correctly. Place the letter associated with that choice (A,B,C or D) in the numbered blank space on your ANSWER SHEET. DO NOT WRITE ON THIS TEST!!! To master this exam you must answer 19 out of 20 items correctly, 90 %.

EVALUATION SHEET

WRITTEN CRITERION EXAM
"PREPARE SOLUTIONS"

Select the BEST answer.

1. Solutes, such as salts, break into changed particles called _____.

   A. electrolytes.
   B. ions.
   C. molecules.
   D. atoms.

2. The chemical with the highest degree of purity used in the clinical laboratory is

   A. chemically pure.
   B. analytical reagent grade.
   C. saturated solution.
   D. chemical reagent grade.

3. Preparation of solutions requires the use of _____glassware.

   A. graduated
   B. volumetric
   C. serological
   D. measured

4. Equipment and supplies used by all laboratory workers are to be free of _____.

   A. defects.
   B. inspection.
   C. breakage.
   D. overuse.

5. One of the greatest responsibilities facing laboratory staff mem-ers is proper _____of patients, their specimens and their laboratory reports.

   A. Identification
   B. recognition
   C. clarification
   D. recording

6. _____are substances, usually liquids, that dissolve a solid.

   A. Solutes
   B. Solvents
   C. Solutions
   D. Molars

EVALUATION SHEET

WRITTEN CRITERION EXAM (Cont.)

7. This formula may be used to calculate molarity:

$$\text{Molarity} = \frac{\text{number of grams of solute}}{\text{molecular weight in grams}} \times \frac{1}{\text{liters of solution.}}$$

A. liters of solution.
B. gram molecular weight.
C. liter quantities.
D. equivalent weights.

8. This technique assures precise _____ weighings and measurements that are practiced in the clinical laboratory.

A. qualitative analysis
B. quantitative transfer
C. pipetting technique
D. qualitative transfer

9. To insure liquid reagents used in clinical tests be free of bacterial contamination, check for _____, a sign of bacterial growth.

A. odor
B. moisture
C. deterioration
D. turbidity

10. For the titration procedure a clean, calibrated _____ or similar device must be used.

A. tube
B. flask
C. pipette
D. buret

11. _____ is the number of gram molecular weights of a compound per liter of solution.

A. Solutions
B. Suspensions
C. Scales
D. Molarity

EVALUATION SHEET

WRITTEN CRITERION EXAM (Cont.)

12. The following formula may be used to calculate normality:

$$\text{Normality} = \frac{\text{gram molecular weight/total positive change}}{\text{X}} \times \frac{1}{\text{liters of solution}}$$

A. equivalents of solute.
B. number of grams of solute
C. number of moles of solute
D. molecular weight in grams

13. Clinical laboratory _____ must be precise, accurate and reliable to be useful in diagnosing disease.

A. procudures
B. tests
C. methods
D. preparations

14. Several procedures ensuring precision, accuracy and reliability of results of clinical laboratory determinations are duplicate analysis, reagent blanks, control solutions, reference materials, and

A. stock standards.
B. quantitative transfers.
C. standard solutions.
D. prepared samples

15. Some fundamental rules to follow when handling and storing chemicals include replacing covers, storing flammables in a cool area, handling volatile substances under a fume hood, and storing dry chemicals in a _____ place.

A. cool, dry
B. wet, moist
C. cool, moist
D. flat, cool

16. Titration requires the addition of a solution of known concentration called a _____, to an accurately measured volume of sample.

A. indicator
B. titrant
C. solvent
D. standard

17. The technique used to calculate the volume of a reagent solution needed to react with a specific volume of a sample is

A. quantitative transfer.
B. quality control.
C. standard solutions.
D. titration.

18. All glassware used for diluting or preparing reagents and measuring samples must be

A. pre-examined.
B. calibrated.
C. non-breakable.
D. stored.

19. The point of a titration reaction is often determined by using a chemical _____, weak acids or weak bases.

A. base
B. indicator
C. reagent
D. standard

20. The major source of error in the clinical laboratory is worker _____. which can develop in even the most highly trained indeviduals.

A. overconfidence
B. performance
C. calculations
D. carelessness

LAKE COUNTY AREA VOCATIONAL CENTER

COMPETENCY-BASED INDIVIDUALIZED VOCATIONAL EDUCATION INSTRUCTION

STUDENT LEARNING GUIDE

Produced By Rosemarie Meyer, RN, BSN Date 4/85

TASK: PERFORM MONONUCLEOSIS TEST (HIGH TECH)

PURPOSE: INFECTIOUS MONONUCLEOSIS IS AN IMPORTANT ACUTE INFECTIOUS DISEASE, PROBABLY VIRAL IN ORIGIN. THREE DISTINCT GROUPS OF ANTIBODIES ARE FOUND IN MONONUCLEOSIS: HETEROPHIC, EPSTEIN-BARR VIRUS (EB'), AND MULTIPLE AUTOANTIBODIES, ISOANTIBODIES, AND HETEROANTIBODIES. HETEROPHIL ANTIBODIES ARE MUCH MORE EASILY DETECTED, AND FOR THIS REASON ROUTINE TESTS FOR THE PRESENCE OF HETEROPHIC ANTIBODIES ARE USED FOR THE DIAGNOSIS OF INFECTIOUS MONONUCLEOSIS, ALONG WITH HEMATOLOGIC FINDINGS. THIS LEARNING GUIDE WILL ASSIST THE STUDENT TO PERFORM A MONONUCLEOSIS TEST.

MEDICAL ASSISTING

emf

Program	Task	Est.Time	Prereq.
07.0904	565	4	

LEARNING CONTRACT (optional)

1. STUDENT DATA

NAME

4 H

SOCIAL SECURITY NUMBER

LENGTH OF CONTRACT (NORMAL TIME IN HOURS)

2. TERMINAL PERFORMANCE OBJECTIVE

Given the necessary tools and equipment, perform a mononucleosis test. To master this task you must score 9 out of 10 (90%) on a written evaluation test and 10 out of 11 (90%) on a performance checklist.

2a. INTERMEDIATE OBJECTIVE(s)

1. Describe mononucleosis.
2. Perform mononucleosis test.

3. AGREEMENT

I, _____ agree to complete the above stated terminal performance requirement within _____ to _____. I further recognize that the conditions of the contract (performance and time agreement) report my ability to perform the requirements of the occupation and record my progress.

Student's Signature

Instructor's Signature
(verifies competency)

Program	Task	Page
07.0904	565	2

INTERMEDIATE OBJECTIVE #1

DESCRIBE MONONUCLEOSIS.

LEARNING STEPS (Activities)

1. Read Resource #1 for information on mononucleosis.

2. Complete Resource #2 for a review on mononucleosis.

3. Proceed to Resource #3.

RESOURCES

1. Information Sheet 565-001-001, "Infectious Mononucleosis," pg. 4 , in this SLG.

   (Information taken from Basic Techniques for the Medical Laboratory by J. Jorgenson and K. Ringsrud, 2nd edition.

2. Job Sheet 565-001-002, "Review Mononucleosis," pg. 7 , in this SLG.

   See activity key book or instructor for evaluation.

3. I.O. #2, pg. 10, in this SLG.

INFORMATION SHEET

565 - 001 - 001

"INFECTIOUS MONONUCLEOSIS"

Infectious mononucleosis is an important acute infectous disease, probably viral in origin, that is represented by a relatively well-defined hematologic picture. Three distinct groups of antibodies are found in infectious mononucleosis: heterophil antibodies, Epstein-Barr virus (EBV) antibodies, and multiple autoantibodies, isoantibodies, and heteroantibodies. Heterophil antibodies are antibodies that react with an antigen entirely different from the phylogenetically unrelated to the antigen responsible for their production. They are agglutinins that react particularly to sheep and horse red cells and are mainly class G immunoglobulins (IgG). Heterophil antibodies are detected by the Paul-Bunnell test.

Infectious mononucleosis is now thought to be caused by the EBV, a member of the herpes group of viruses. Antibodies to this virus are produced early in the disease and can be detected by complement fixation tests and immunofluorescence techniques. Demonstration of EBV antibodies is a complicated process and is beyond the scope of most routine laboratories. Heterophil antibodies are much more easily detected, and for this reason routine tests for the presence of heterophil antibodies are used for the diagnosis of infectious mononucleosis, along with hematologic findings.

Heterophil antibodies are present in low titer in the serum of normal persons and are known as Forssman antibodies. They resemble the antibodies found in infectious mononucleosis in that they agglutinate sheep red cells, but differ from them in that they are absorbed by an emulsion of guinea pig kidney, which is rich in Forssman antigen, and are not absorbed by beef cells, which are poor in Forssman antigen. In cases of serum sickness, or sensitization to animal (usually horse) serum, a further type of sheep red cell agglutination antibody is found and may be present in high titer. However, this is again distinguished from the antibody of infectious mononucleosis by being absorbed by guinea pig kidney and from Forssman antibodies by being absorbed by beef red cells. This is summarized in Table 8-1. This comparison was devised by Davidsohn in 1935 to 1937 and is used today as the basis for presumptive and differential tests.

TABLE 8-1. Comparison of Forssman, serum sickness, and infectious mononucleosis antibodies

	ABSORBED BY	
Antibody	Guinea pig Kidney	Beef red blood cells
Forssman	Yes	No
Serum sickness	Yes	Yes
Infectious mononucleosis	No	Yes

The sheep cell agglutinins of infectious mononucleosis can be distinguished from those of serum sickness and other conditions by means of a differential test, using absorption with guinea pig kidney and beef red cell antigens. The antibody that can be removed by absorption with guinea pig kidney is known as the Forssman antibody, and the guinea pig kidney as the Forssman antigen. The classical sheep red cell agglutination test is carried out in two steps: the presumptive test of Paul and Bunnell, and the differential test of Paul, Bunnell, and Davidsohn. These are the reference tests from which the rapid testing procedures have evolved. Modifications of these classical procedures utilize horse red cells instead of sheep red cells.

Under normal circumstances, rapid screening tests for infectious mononucleosis are done for the presence of heterophil antibodies. Horse red cells are usually used rather than sheep red cells, as they are more sensitive to heterophil antibodies. Persons suffering from infectious mononucleosis begin developing heterophil antibodies shortly after the appearance of the symptoms, usually during the first 2 weeks. Highest titers are found during the second and third weeks of the illness. The titer bears no relationship, however, to the severity of the illness. As a rule, heterophil sheep cell agglutinins appear in only 50-80 percent of cases of infectious mononucleosis, so negative results can be obtained when the disease is present. Negative tests therefore do not rule out the possibility of the disease.

The test for heterophil antibodies is of confirmatory diagnostic importance in cases of infectious mononucleosis with typical clinical and hematologic findings. It is of a deciding diagnostic importance early in the disease when there are unusual clinical findings and hematologic signs, some of which may be caused by complicating factors.

Recently, faster and easier screening tests have been introduced commercially and have replaced the laborious presumptive and differential tests in many laboratories. One such test is the spot test of Lee et al. These rapid slide screening tests are based on the following principles: (1) the use of horse red cells instead of sheep red cells makes the test more sensitive and thus is especially valuable for low-titer serum found in the early stages of the disease; (2) the unwashed preserved horse red cells remain in a usable condition for at least 3 months and give stronger and quicker agglutination with infectious mononucleosis serum than do horse red cells preserved with Formalin; (3) some noninfectious mononucleosis serum also has a high horse agglutinin titer, and therefore serological tests cannot depend on titers alone; and (4) fine suspensions of guinea pig kidney and of beef red cell stromata give satisfactory instant absorption of antibodies and a clear-cut differentiation between infectious and noninfectious mononucleosis serum.

These tests are done on a slide. The serum from the patient is mixed thoroughly with guinea pig kidney on one spot of the slide and with beef red cell stromata on another spot. The unwashed horse red cells (preserved) are added immediately to both spots. These reagents are available commercially in the form of test kits. Directions must be followed carefully. Agglutination is observed on both spots of the slide 1 minute after the final mixing. If agglutination

is stronger on the spot where the guinea pig kidney suspension was mixed with the patient's serum, the test is positive. If it is stronger on the spot where the beef red cells were mixed with the patient's serum, the test is considered negative. If the agglutination is equal on both spots, the test is negative. If no agglutination appears on either spot, the test is negative. One commercially available test kit utilizing this principle is called Mono-Spot and is manufactured by Ortho Diagnostics, Raritan, NJ.

The glass slides used for these rapid screening tests must be carefully cleaned under running water. Use of detergent could cause errors in the results. Most of the widely used immunologic assays for infectious mononucleosis are highly sensitive. It is still necessary, however, to use adequate and proper control programs as the only dependable method of detecting sources of technical errors. When the results are not clearcut, it is always important to repeat them and to conduct additional dependable serological tests. Several tests are available. Repeating tests at a later date is also helpful.

JOB SHEET

565-001-002

"REVIEW MONONUCLEOSIS"

SELECT THE BEST ANSWER.

1. Infectious mononucleosis is an important acute infectious disease, probably _____ in origin, and well-represented by a well-defined hematologic picture.

   A. infectious
   B. serous
   C. viral
   D. fungal

2. Infectious mononucleosis is now thought to be caused by _____, a member of the herpes group of viruses.

   A. heterophil
   B. IgG
   C. Forssman
   D. EBU

3. Heterophil antibodies are present in low titer in the serum of normal persons and are known as _____.

   A. Epstein-Baan antibodies
   B. Autoantibodies
   C. Isoantibodies
   D. Forssman antibodies

4. In cases of serum sickness, or sensitization of animal (usually horse) serum, a type of sheep red cell agglutination antibody is found and may be present in _____ titer.

   A. high
   B. low
   C. neutral
   D. iso

5. The cell agglutinins of infectious mononucleosis can be distinquished from those of serum sickness and other conditions by means of a differential test.

   A. horse
   B. rabbit
   C. sheep
   D. beef

6. The antibody removed by absorption with guinea pig kidney is known as the Forssman _____.

   A. antigen
   B. antibody
   C. agglutinin
   D. titer

7. Rapid screening tests for infectious mononucleosis are done for the presence of _____ antibodies.

   A. EBU
   B. heterophil
   C. heteroantibodies
   D. isoantibodies

8. Patients suffering from infectious mononucleosis begin developing heterophil antibodies shortly after the appearance of symptoms, usually during the first _____ weeks.

   A. two
   B. three
   C. four
   D. five

9. _____ titers are found during the second and third weeks of illness.

   A. Lowest
   B. Normal
   C. Highest

10. The test for heterophil antibodies is of confirmatory diagnostic importance in cases of infectious mononucleosis with typical clinical and _____ findings.

    A. screening
    B. differential
    C. comparing
    D. hematologic

11. One faster and easier commercial screening test is the _____ test.

    A. mono
    B. serum
    C. IgG
    D. spot

12. The rapid slide test is _____ when agglutination appears on both spots.

    A. positive
    B. negative

13. The commercial agglutination test kit used in the M.A. lab is _____.

    A. Lee et al
    B. mono
    C. UCG
    D. EBU

14. Glass slides used for rapid screening tests must be cleaned under running water. Use of _____ could cause errors in the results.

    A. disinfectants
    B. detergents
    C. antiseptics
    D. solutions

15. It is necessary to use adequate and proper _____ programs as the only dependable method of detecting sources of technical errors.

    A. sample
    B. specimen
    C. control
    D. labeling

INTERMEDIATE OBJECTIVE #2

PERFORM MONONUCLEOSIS TEST.

LEARNING STEPS (Activities)

1. Observe Resource #1 for a demonstration on performing a mononucleosis test.
2. Practice performing a mononucleosis test by completing Resource #2.
3. When you feel you have mastered this task, complete Resource #3.
4. Complete Resource #4 for a written evaluation.
5. Proceed to Resource #5 for the next learning guide.

RESOURCES

1. See instructor.
2. Job Sheet 565-002-002, "Practice Performing a Mononucleosis Test," Pg. 11, in this SLG.
3. Performance Checklist, pg.13 , in this SLG.

   See instructor for evaluation.
4. Written Criterion Examination, "Perform Mononucleosis Test," in LRC.

   See LRC secretary.
5. See instructor.

JOB SHEET

565-002-002

"PRACTICE PERFORMING A MONONUCLEOSIS TEST"

DIRECTIONS TO THE STUDENT:

Given the necessary tools and equipment, practice performing a mononucleosis test.

NECESSARY TOOLS AND EQUIPMENT:

Mono spot kit
Wholeblood (Capillary or Venous)

PROCEDURE:

TESTING OF SPECIMENS

1. Fill capillary with patient's specimen up to mark and empty into center of middle section of the slide.

2. Place one drop of Negative Control Serum in right section and one drop of Positive Control Serum in left section of the slide.

3. Add one drop of MONO-TEST Reagent to each section of the slide.

4. Mix separately, and spread each mixture uniformly over an area approximately 1 inch in diameter. Use a clean disposable stirrer for each mixture.

USING GLASS SLIDE

5. Rock slide gently for 2 minutes and observe immediately for agglutination by using a high intensity lamp for lateral illumination of the slide and observing against a dark background.

USING DISPOSABLE CARD SLIDE

5. Rock card gently for 1 minute, then leave it undisturbed for another 1 minute, and observe immediately for agglutination.

TITRATION PROCEDURE

Although the heterophile antibody titer has been said to bear no relation to the severity or cause of the disease, some laboratories are requested to establish an antibody titer, particularly as a sequential determination for an individual patient.

The specimen is titered by preparing 2-fold serial dilutions from 1:2 to 1:32 in isotonic saline (0.85% sodium chloride) and testing each dilution with MONO-TEST Reagent.

1. Place 5 test tubes into a test tube rack and label them #1 - #5.

2. Dispense 0.5 ml of isotonic saline into each tube.

3. Add 0.5 ml of specimen to tube #1, mix thoroughly.

4. Transfer 0.5 ml from tube #1 to tube #2, mix thoroughly.

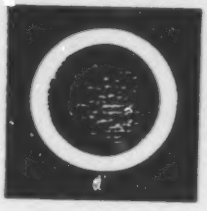
5. Continue transferring 0.5 ml aliquots from tube #2 through tube #5, mixing thoroughly before each transfer. It is not necessary to discard 0.5 ml from tube #5 (the 1:32 dilution); this may be retained should further dilutions be required.

6. Test the undiluted specimen along with each dilution as described under Testing of Specimens."

RESULTS

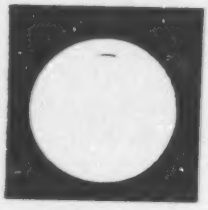
Specimens which contain serologically detectable I.M. antibodies will agglutinate the MONO-TEST Reagent. Agglutination (clumping) of the MONO-TEST Reagent is interpreted as a positive result. No agglutination of a finely granular pattern should be reported as a negative result.

The following pictures illustrate positive and negative results:



POSITIVE

NEGATIVE



The I.M. titer of a specimen is interpreted as the reciprocal of the last dilution to produce a positive result(end point).

PERFORMANCE/PRODUCT CHECKLIST

Program: MEDICAL ASSISTING

Task No: 565

Student's Name: _____ Date Of Attempt: _____

Evaluator's Name: _____ Evaluation Site: _____

Performance Attempt: 1 2 3 4

Terminal Performance Objective:

Given the necessary tools and equipment, perform mononucleosis test.

Directions To The Student:

Before attempting this task for mastery, carefully review this checklist. You will be evaluated on the basis of this checklist. When you feel you are ready for evaluation, contact your instructor. You must complete your performance within 10 minutes and must score at least 10 out of 11 points or 90 % for mastery. Critical items are marked with an asterisk (*). These items must be satisfactorily completed.

Directions To The Evaluator:

The student will contact you when ready for the evaluation. The student must complete the performance within 10 minutes and must score 10 out of 11 points or 90 % and all items marked with an asterisk (*) must be satisfactorily completed.

CRITICAL ITEMS	ITEMS TO BE OBSERVED OR CHECKED	RATING YES	RATING NO
*	1. Wash hands.		
*	2. Fill capillary up to mark.		
*	3. Empty into center of middle section of the slide.		
*	4. Place one drop of Negative Control Serum on right side of slide.		
*	5. Place one drop of Positive Control Serum on left side of slide.		
*	6. Add one drop of Mono Test Reagent to each section of the slide.		
*	7. Mix separately.		
*	8. Spread uniformly.		
	9. Rock glass slide gently for 2 minutes or on disposable card for 1 minute.		
*	10. Read and record results.		
*	11. Clean up working area.		

TOTAL POINTS EARNED =

POINTS NEEDED FOR MASTERY = 10
TOTAL POINTS POSSIBLE = 11

MEDICAL ASSISTING

PROGRAM 07.0904

CRITERION EXAM

TASK = 565

DIRECTIONS:

THE PURPOSE OF THIS EXAM IS TO DETERMINE WHETHER OR NOT YOU HAVE UNDERSTOOD THE INFORMATION ON PERFORM MONONUCLEOSIS TEST.

Each of the questions or incomplete statements below is followed by several words, phrases, or a series of numbers. Choose the one which best answers the question or completes the statement correctly. Place the letter associated with that choice (A,B,C or D) in the numbered blank space on your ANSWER SHEET. DO NOT WRITE ON THIS TEST!!! To master this exam you must answer 9 out of 10 items correctly, 90 %.

EVALUATION SHEET

WRITTEN CRITERION EVALUATION

"PERFORM MONONUCLEOSIS TEST"

SELECT THE BEST ANSWER.

1. Infectious mononucleosis is an important acute infectious disease, probably _____ in origin, and well-represented by a well-defined hematologic picture.

   A. infectious
   B. serous
   C. viral
   D. fungal

2. The cell agglutinins of infectious mononucleosis can be distinquished from those of serum sickness and other conditions by means of a differential test.

   A. horse
   B. rabbit
   C. sheep
   D. beef

3. _____ titers are found during the second and third weeks of illness.

   A. Lowest
   B. Normal
   C. Highest

4. The commercial agglutination test kit used in the M.A. lab is _____.

   A. Lee et al
   B. mono
   C. UCG
   D. EBU

5. It is necessary to use adequate and proper _____ programs as the only dependable method of detecting sources of technical errors.

   A. sample
   B. specimen
   C. control
   D. labeling

6. Reasons suffering from infectious mononucleosis begin developing heterophil antibodies shortly after the appearance of symptoms, usually during the first _____ weeks.

   A. two
   B. three
   C. four
   D. five

7. The rapid slide test is _____ when agglutination appears on both spots.

   A. positive
   B. negative

8. The antibody removed by absorption with guinea pig kidney is known as the Forssman _____.

   A. antigen
   B. antibody
   C. agglutinin
   D. titer

9. One faster and easier commercial screening test is the _____ test.

   A. mono
   B. serum
   C. IgG
   D. spot

10. Rapid screening tests for infectious mononucleosis are done for the presence of _____ antibodies.

    A. EBU
    B. heterophil
    C. heteroantibodies
    D. isoantibodies